RESOURCE CONSERVATION

GUIDE TO Resource Conservation and Cost Savings Opportunities in the ➲ Soap, Detergents and Related Products Sector

Ministry of the Environment

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Guide to Resource Conservation and Cost Savings Opportunities in the Soap, Detergents and Related Products Sector

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by:

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DISCLAIMER

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Similarly, the generic opportunities presented by the authors of this guide do not represent recommendations for implementation at specific sites. The authors of the guide are not responsible for any such implementation without prior consultation and further detailed site evaluation.

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Additional copies of the "Guide to Resource Conservation and Cost Savings Opportunities in the Soap, Detergent and Related Products Sector" are available from the Industry Conservation Branch.

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EXECUTIVE SUMMARY

PURPOSE

The "Guide to Resource Conservation and Cost Savings Opportunities in the Soap, Detergent and Related Products Sector" was prepared to help those involved in the manufacturing of such products to identify potential process improvements that will reduce production costs and conserve resources.

The guide offers a series of generic process descriptions and checklists of improvement opportunities specific to each of five major processes used in the manufacture of soap and detergent products. The five major processes are:

- Soap production;
- Surfactant production;
- Solid cake product formulation;
- Liquid product formulation; and
- Granulated powdered product formulation.

The guide is intended to be a helpful tool that can be used in combination with existing skills and knowledge among clients who are involved in the soap and detergents processing sector. Individuals and client groups include: facility-owners; managers; employees; product and technology suppliers; engineering designers; consultants; and related associations.

KEY OPPORTUNITY HIGHLIGHTS

The most important opportunities for soap, detergent and related products manufacturing result from the reduction of product losses, irrespective of the process involved. The value of materials lost through waste, effluent discharge or other losses is typically much higher than the cost of disposal, treatment or surcharges that may be incurred. In some cases the product value can be as much as ten times higher or more. Reduction of product losses thus yields a substantial double benefit, simultaneously increasing saleable product revenues and reducing treatment or disposal charges.

Additional significant opportunities may also be present in the improvement of utility and service systems at manufacturing plants, including: steam; heating; hot water; cooling; and compressed air. Such opportunities result in reduced energy costs, and often involve low cost or operational improvements, that can be rapidly implemented with little or no capital requirements. Achieving improvements in utilities and services is closely linked to the use of unit performance ratios for energy and water consumption. The use of these ratios for bench marking, can assist in quickly identifying key opportunity areas.

STRUCTURE

The information featured in this guide is outlined as follows:

Chapter 1	**Introduction**, outlines the purpose of the guide and the intended target audience.
Chapter 2	**Sector Profile**, outlines a context for exploring resources conservation and cost savings opportunities in Ontario's soap and detergents processing sector. It provides a "snapshot" of the sector and includes summaries of a number of key variables such as the current number and size of plants, economic status, product trends, sector environmental successes and emerging issues.
Chapter 3	**Products and Generic Processes**, outlines the rationale as well as the generic processes selected for examination of resource conservation and cost savings opportunities. Five generic process descriptions are provided, as well as the typical utility and service demands. Limitations of the generic approach adopted for this guide are also described.
Chapter 4	**Resources Utilization**, describes the wide range of energy, water and material resources that are commonly used in relation to the various generic processes.
Chapter 5	**Bench Marking**, describes the calculation and use of unit performance ratios for bench marking the use of thermal energy, electricity and water, the generation of environmental residuals, and associated product losses.
Chapter 6	**Process Residuals**, describes the air-borne, water-borne, hazardous and solid waste residuals that are commonly derived from the various generic processes.
Chapter 7	**Generic Process Improvement Opportunities**, provides concise generic checklists to assist in identifying process related improvement opportunities incorporating energy/water efficiency and pollution prevention. Each tabulated checklist summary identifies thermal, electrical, environmental and water use implication, low cost/no cost measures that can be implemented, retrofit technology options and general comments.
Chapter 8	**New Technologies**, identifies and describes a variety of new technologies that may exhibit future potential.
Chapter 9	**Regulatory Overview**, provides a brief overview of relevant regulations, especially environmental, affecting the industry.

Chapter 10 **Other Helpful Information**, outlines a variety of other information including Environmental Management Systems (EMS), average retrofit payback period data for generic heat recovery and process retrofit opportunities, available reference documents, and website locations.

Appendix I **Glossary**, provides definitions for the applicable acronyms used throughout the guide.

Appendix II **Background on Soap, Detergents and Related Products Industry in Ontario**, provides a definition of the sector, the number of relevant establishments, and the economic status.

Appendix III **Major Product Ingredient Categories**, describes the four major categories of ingredients, including: surfactants; builders or sequestering agents; other additives; and acid or caustic agents.

Appendix IV **Background on Advanced Analysis Methodologies**, includes a copy of a recent paper by the author of the guide describing analysis methodologies in greater detail, as well as providing additional source references.

Appendix V **Aggregate Summary Data on Energy Improvement Opportunities from Industrial Energy Services Program (IESP), MOEE**, provides aggregate capital cost and energy savings data for a range of improvement opportunities recommended at sites by IESP analyses.

Follow-up Services Available

The Industry Conservation Branch of the MOE can provide assistance to companies developing a resource conservation plan.

Utility bill analysis is a service offered to Ontario companies as a first step in conducting a resource-use assessment of a plant. The analysis provides a quick indicator of an individual company's energy and water consumption patterns and the efficiency of operations. Immediate savings can often be identified in the analysis of gas, electricity, oil, propane, and water consumption patterns.

A follow-up plant "walk-through" analysis identifies potential operational savings in energy, water and other process-related resource use in the facilities. Companies can then pursue resource conservation opportunities using their own technical staff or with the assistance of an external consultant.

Contact the Industry Conservation Branch, Manager, Clean Production Services at (416) 327-1453 for more information on any of these services.

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List of Exhibits

1.0 INTRODUCTION

Soaps, detergents and related products are used for cleaning purposes in industrial, institutional and domestic consumer applications. The soap, detergents and related products sector is an important component of the chemical industry within Ontario. This guide was prepared for the Industry Conservation Branch (ICB) of the Ontario Minstry of Environment (MOE) to assist the sector with cost savings and resource conservation. The intent of the guide is to highlight opportunities for resource conservation through energy and water efficiency improvement, more efficient utilization of raw materials, and reduction of environmental releases at source.

1.1 PURPOSE

The purpose of this guide is to encourage those who play a role in manufacturing processes to consider and, where appropriate, implement process refinements in order to conserve resources and minimize production costs. The audience for this guide includes all stakeholders in the manufacturing processes. These include processing plant owners, managers, employees, entrepreneurs, product/technology suppliers, designers, consultants and related associations.

1.2 HOW TO USE THIS GUIDE

For the reader who wishes to proceed directly to a specific process of interest, suggestions on "how to use this guide" are provided in Exhibit 1.1 and Exhibit 1.2. Starting points in the text (i.e. key exhibits) are identified in Exhibit 1.1. Areas of interest such as utility and service requirements, new technologies and sources of additional information are identified in Exhibit 1.2 (i.e. key exhibits/sections).

Exhibit 1.1: Starting Points for Processes

PROCESS	GO TO
Soap Production	Exhibit 3.2
Surfactant Production	Exhibit 3.3
Solid Cake Product Formulation	Exhibit 3.4
Liquid Product Formulation	Exhibit 3.5
Granulated Powdered Product Formulation	Exhibit 3.6

Exhibit 1.2: Starting Points for Subjects

SUBJECT	GO TO
Utilities and Services:	
Descriptions	Exhibit 3.7
Improvements Checklist	Exhibit 7.7
New Technologies	Section 8.0
Process Residuals:	
Water	Section 6.1
Air	Section 6.2
Solid Waste	Section 6.3
Resource Utilization:	
Energy	Section 4.1
Water	Section 4.2
Materials	Section 4.3
Performance Ratios	Section 5.0
Sources of Additional Information	Section 10.0
Sector Profile	Section 2.0

2.0 SECTOR PROFILE

A brief profile of the soap and detergents, and related products sector is presented in the following sections. More detailed background on the sector is provided in Appendix II.

2.1 SECTOR DEFINITION

Soap, detergents and related products represents a sub-sector under the Formulated Products and Specialty Chemicals (FPSC) market. FPSC represents a collection of products/sub-sectors that forms part of the overall Chemical Industry, however, it is neither discrete nor well identified. Relevant sub-sector statistics and information are scarce, partly because of overlap between Standard Industrial Classification (SIC) categories as defined by Statistics Canada. (Refer to Appendix II for classification information.)

For the purpose of this guide, the sector is defined to include activities and establishments involved in the various stages of the manufacture of products which are broadly defined to be used for cleaning functions, whether for industrial, institutional or consumer application. Major by-products of these manufacturing processes are also included. Definitions of cleaning product terms, including soap, detergent, surfactant, etc., are provided in Appendix I.

2.2 NUMBER OF ESTABLISHMENTS

It is difficult to assess the precise number of Ontario manufacturing establishments involved with soap, detergents and related products. This is because of cross-over SIC and categorization uncertainties associated with the FPSC market, as described earlier.

Based on an evaluation of publicly available data, there are approximately 100 different establishments directly involved in this sector in Ontario, with likely as many as 90 additional establishment with some involvement in the target sector. Appendix II gives further information on the number of firms.

2.3 ECONOMIC STATUS

The soap, detergents and related products sector in Ontario currently represents total manufacturing shipments of approximately $1.5 billion and total employment of approximately 4,000 within the province. The sector is economically important in two respects:

- Sector within Canada represents a significant component of the overall national chemical industry. This is similarly true in Ontario, where the target sector represents a significant component of the provincial chemical industry.
- Ontario represents a substantial proportion of the target sector on a

national basis.

The sector also manufactures products with a relatively high proportion of value-add, consistently representing just over 50% of the value of manufacturing shipments. The comparable aggregate proportion of value-add for all other manufacturing industries in Canada is only approximately 40% of the value of manufacturing shipments.

2.4 SIZE OF ESTABLISHMENTS

For the classification of establishments by size, criteria based on that presented by the Ontario Ministry of Economic Development, Trade and Tourism (MEDTT) in their 1994 sector profile has been used. Establishments are thus categorized by size as follows:

- *Large* establishments, having more than 500 total employees within the enterprise in Canada.
- *Medium* establishments, having 50 to 499 total employees within the enterprise in Canada.
- *Small* establishments, having up to 49 total employees within the enterprise in Canada.

The current approximate distribution of establishments by size is presented in Exhibit 2.1. This summary of establishment size is based on employee numbers as identified in the 1996 *Scott's Directory*. From this data, the following breakdown is obtained:

- Approximately 4% of establishments can be categorized as Large-sized.
- Approximately 24% of establishments can be categorized as Medium-sized.
- Approximately 72% of establishments can be categorized as Small-sized.

2.5 MARKET CHARACTERIZATION

The market for soap, detergents and cleaners can be described as *mature* in terms of the overall stage of product life-cycle. This is evidenced, for example, by the relative stability in number of manufacturing establishments, total manufacturing shipments, and total domestic market value described in more detail in Appendix II.

The market can be subdivided into three constituent segments, based on end-use application, which are summarized as follows:

- *Consumer* market segment, for personal care, including such products as hand soaps, shampoos, dishwasher and laundry detergents, and related specialty cleaners.
- *Institutional* market segment, including janitorial and housekeeping suppliers for institutions such as hospitals and schools, as well as

commercial buildings, etc.

- *Industrial* market segment, including specialized materials used as part of industrial or business processes.

Analysis presented in the 1995 report of the Ontario Ministerial Advisory Committee on Chemicals (MAC Chem), indicated that the consumer market segment is by far the largest, representing approximately an 80% share of the total market for soaps and cleaning compounds (SIC 3761).[1] Institutional and industrial applications together, represent the remaining 20% share.

A breakdown of total market for SIC 3761 by type of product was developed earlier in an Industry Canada Sector Profile.[2] The approximate breakdown is as follows:

- Soaps, using fats and oils of either animal or vegetable origin as raw materials, represent approximately 10% of total industry shipments.
- Synthetic detergents, using predominantly petrochemical-based surfactant, represent approximately 55% of total industry shipments.
- Other cleaning compounds represent together approximately 35% of total industry shipments.

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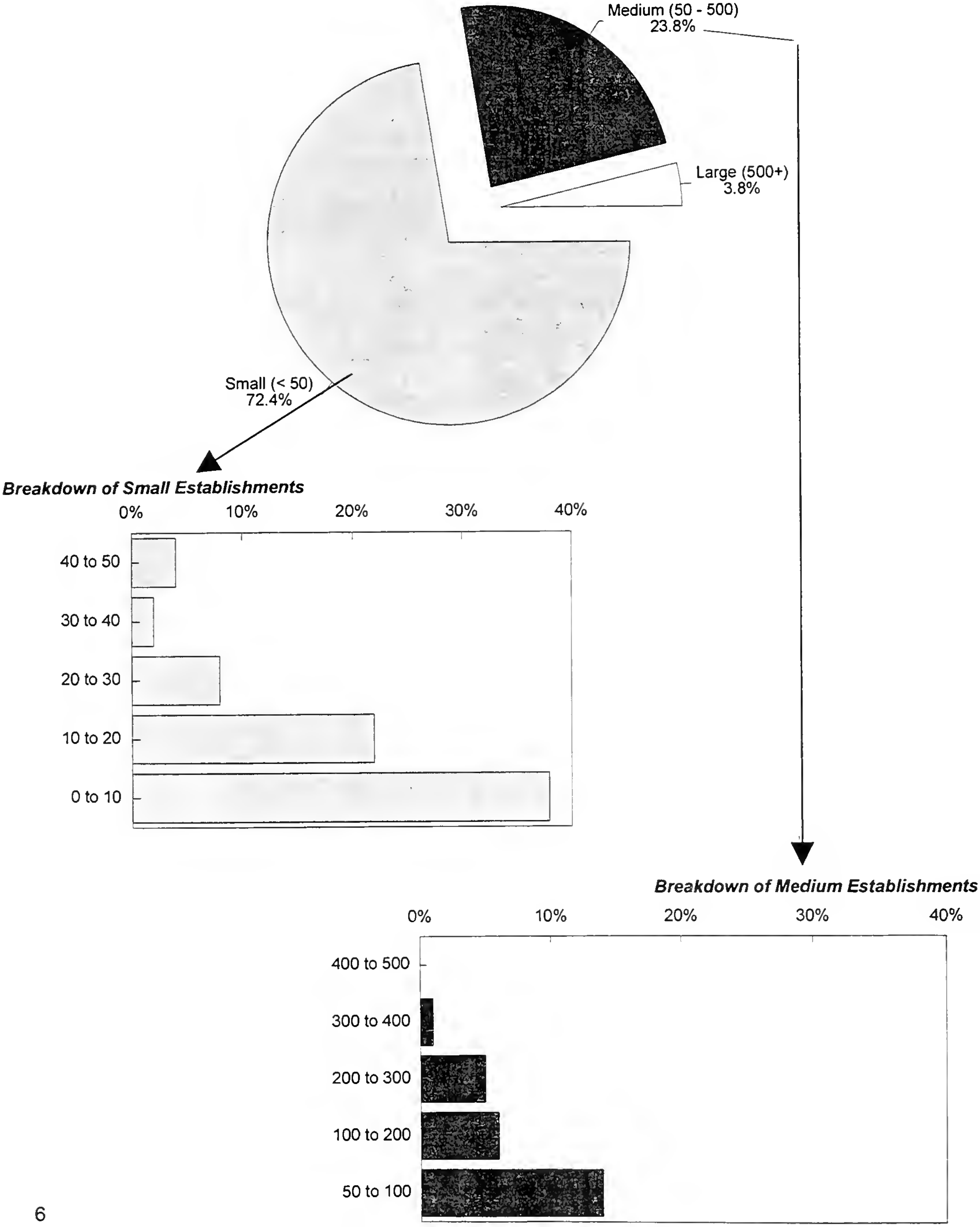
1 Catalyst for Change. The Report of the Ontario Ministerial Advisory Committee on Chemicals. February, 1995.

2 Industry, Science and Technology Canada. 1991. Industry Profile 1990-1991: Soap and Cleaning Compounds.

EXHIBIT 2.1: Primary Establishments by Size (Employees)



While the overall market for soap and detergent products is stable, it is not static. The nature of competition within the industry, which is identified by Porter as one of the major five forces affecting the competitive status of industries, can be characterized as intense and aggressive, especially for consumer products.[3] Important expressions of this nature of the industry include:

- Domination by product brands, especially with regard to consumer products, with associated strong emphasis on brand promotion and advertising;
- Strong price competition;
- Rapid and continual product innovation and associated brand turnover or renewal. Within the industry, "new and improved" has been a consistent product tradition; and
- Concurrent process modifications and upgrades to adapt to product changes.

One key resulting observation, which is important to consider for environmental improvements, is that the industry is much more focused on *products* rather than *processes*.

2.6 INDUSTRY TRENDS

The soap, detergents and related products sector is affected by a number of trends which may trigger changes in the nature and composition of product formulations. Identified important overall trends affecting the industry include the following:

- *Technology.* New developments include both improvements in the constituent chemicals available for inclusion in products, and changes in washing machine technologies. In the latter case, an important development is the impending movement away from conventional vertical axis machines (VAMs) toward high efficiency machines (HEMs), more like European appliances. This will affect formulations, both potentially in the quantity of product used per load, and the requirement for reduced suds.
- *Demographics.* Trends are evident toward an aging population, smaller families, more working women, greater number of single individual households, all of which affect consumer needs and desires for products.
- *Environment.* A number of environmental trends are evident, which can be grouped into the following three interrelated areas:
  - Improvement of energy efficiency, relating both directly to products, such as improved performance using cold water, and indirectly in terms of appliances (as described above);
  - Minimization of environmental residual effects resulting from the ultimate end-use of products, and through product reformulation; and,

3 Porter, M.E. 1990. Competitive Strategy; Techniques for Analysing Industries and Competitors. Free Press.

- Maintenance of environmentally responsible image of products and manufacturers. This relates primarily to addressing consumer consciousness regarding products.

Important resulting product and market trends include the following:

- More concentrated powder detergent products in smaller packages, and greater emphasis on liquid detergent products, again concentrated. Japanese, especially, and European products are more concentrated. North American products have tended to lag, but are still moving to progressively higher levels of concentration.
- Increase in multi-functional nature of cleaning products for improved convenience.
- Improved performance and effectiveness of products overall.
- Improved performance of detergent products specifically using cold water.
- Increased prominence of enzymes within products to increase performance, especially with cold water, and specificity.
- Enhanced anti-microbial activity of soap and cleaning products.
- Reduced product harshness and improved mildness, especially with regard to cleaners.
- Enhanced environmentally friendly nature of products, primarily evident in terms of progressive packaging minimization, and concerns with regard to environmental degradation due to constituent chemical ingredients.

The trends towards freer trade and globalization are also important factors for the industry. As indicated in the 1991 Industry Canada Sector Profile, up until the implementation of the Canada-US Free Trade Agreement (FTA), the industry, with some minor exceptions, did not compete internationally, being focussed primarily on serving the Canadian domestic market. However, this situation has changed. Canadian firms are more actively seeking international markets, and foreign-owned subsidiary operations are tending to focus on a more narrow group of international or continental product mandates.[4]

2.7 ENVIRONMENTAL IMPROVEMENT SUCCESSES

A number of important industry successes can be readily identified. These include the following:

- Reductions of package sizes with advent of more concentrated products. This has reduced the quantity of packaging material employed;
- Responsiveness in modifying products to deal with environmental concerns. The industry has, on various occasions, modified product formulation, for example in the reduction/elimination of phosphate content;

4 Industry, Science and Technology Canada. 1991. Industry Profile 1990-1991: Soap and Cleaning Compounds.

- Improved product performance at lower temperatures, requiring less water heating; and
- Improved product efficiency.

2.8 EMERGING SECTOR ISSUES

Important emerging sector issues include the following:

- *Classification of Products as Drugs.* Certain anti-microbial soap and cleaning products require registration as drugs, as described later in Section 9.5. The regulatory and procedural requirements are the same as for prescription drugs, even though the products are intended only for surface skin contact. This classification is both cumbersome and expensive in terms of manufacturing. This concern may become increasing important given the trend toward anti-microbial in soap products.

- *Endocrine Disruption.* Certain synthetic and natural compounds have been identified to have estrogenic properties, mimicking the effects of female hormones and causing disruptive impacts in the environment.[5] Substantial literature has begun to emerge on this subject, both scientific and popular. Concerns have been raised by environmental groups regarding such potential effects due to certain ingredients in detergents, specifically Alkyl Phenol Ethoxylates (APEs), which are a class of non-ionic surfactant. Some information is available describing apparent effects of APE and related breakdown products in a laboratory setting. However, the evidence regarding adverse effects of APE in the environment appears to be more circumstantial and far from conclusive.[6] Nevertheless, APE has been banned by various European countries. More recently within Ontario, the World Wildlife Fund Canada released selected testing results of 30 commercial products, indicating seven which contained some concentrations of APE.[7] Work is underway to provide better quantification of environmental and human effects is described in Section 6.4. The issue of APE in products will continue to be important, given both the uncertainties involved and public concern over potential health and environmental impacts.

- *Enzymes.* Enzymes are increasing in popularity as ingredients of soap, detergent and other cleaning products. These constituents exert specific biological activity. As such, they may pose concerns regarding both health and safety, and environmental effect when present at higher concentrations, as in the case of manufacturing operations. The Soap and Detergents Association of Canada (SDAC) has proposed an

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5 Sedlak, R. 1996. Safety and Regulatory Issues Affecting Cleaning Products. New Horizons: An AOCS/CSMA Detergent Industry Conference. AOCS Press. pp1-17.

6 For example refer to: http://easyweb.easynet.co.uk/~mwarhurst/ape.html.

7 The Toronto Star. Wednesday, February 12. 1997. Cleansers Cause Fears Over Cancer. pA8.

enzyme handling safety protocol that will, once approved by the industry, provide guidelines to companies handling these compounds.

3.0 PRODUCTS AND GENERIC PROCESSES

Soaps, detergents, cleaners and other related products represent formulated preparations which combine a variety of constituent ingredients to achieve a desired performance. These products can also be prepared in a number of different formats, for example granular powders versus liquids. It is the nature of the ingredients in the product formulation and the product form that determine the process requirements, and thus the resource intensity and associated residual effects of any given process.

3.1 OVERVIEW OF PRODUCTION SEQUENCE

In categorizing plants and processes, a generalized two-stage sequence of manufacturing operations is typical for the soap, detergents and related products sector, as illustrated in Exhibit 3.1. These two stages are summarized as follows:

- *Primary* or active ingredient production, which typically involves chemical transformation or extraction activities using petrochemical or natural source materials; and
- *Secondary* or product formulation, which typically involves mixing, blending, dosing, drying, granulation, and packaging activities.

Two important sources of raw materials for active ingredients are involved:

- Natural sources, which can include plant or animal derivatives. Examples are palm oils or tallow, which are used in the manufacture of soap; and
- Petrochemical sources, which are employed for synthetic product manufacture.

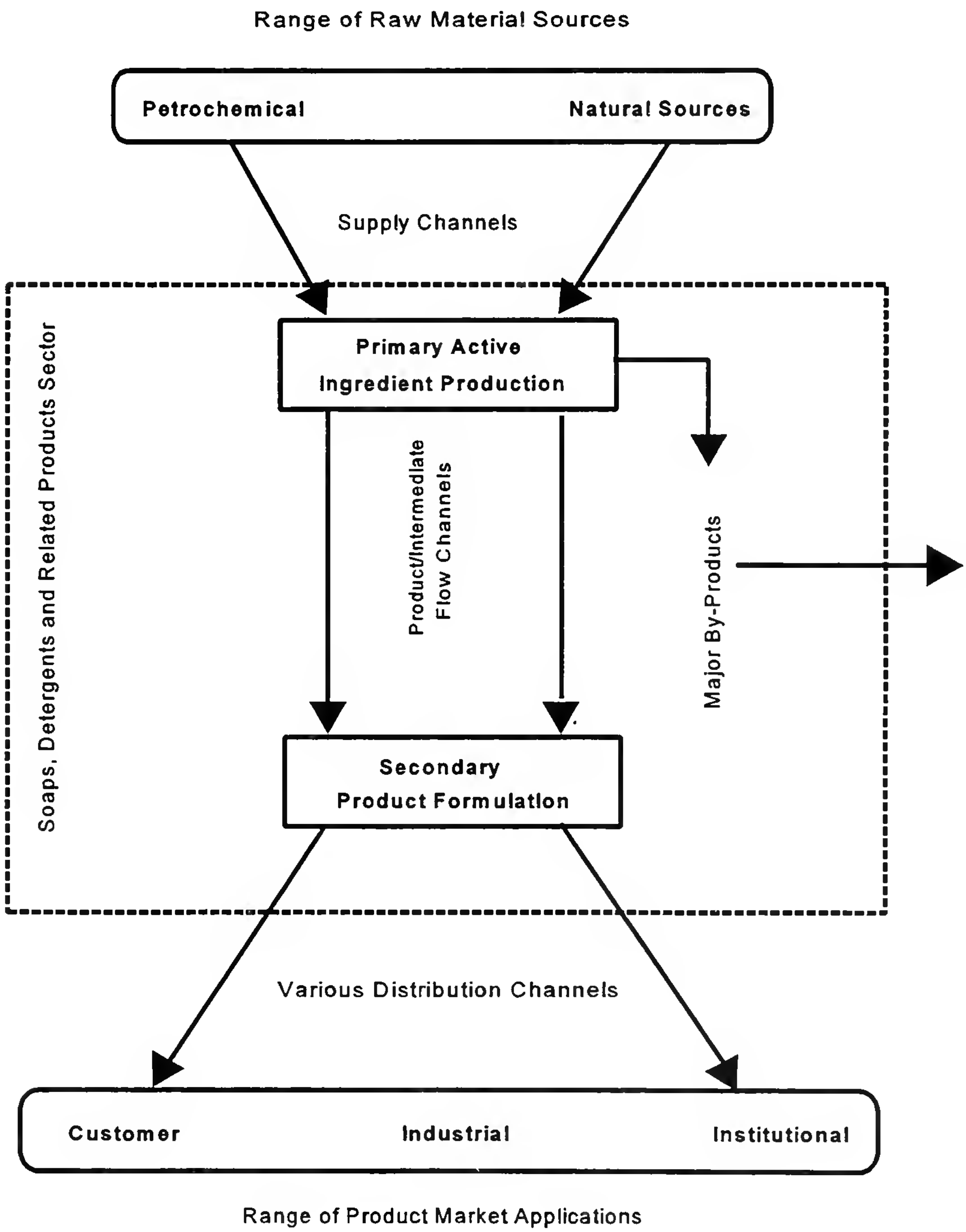
More information about the nature of input ingredients is provided in Chapter 4.3.

As indicated in Exhibit 3.1, by-products also may be generated by the *primary* activities, and the processing of these by-products is also relevant to consider.

Within both primary or secondary production activities, specific processes may be operated in either of the following ways:

- *Dedicated process* to a specific product; or
- *Flexible process* to handle a variety of relatively similar products. Multiple products may be prepared within a given operational system. This may be particularly important for specific facilities given rapid product modifications and upgrades.

EXHIBIT 3.1: Generalized Primary and Secondary Production Sequence



3.2 FINAL PRODUCT FORMATS

Final products are prepared in a number of forms. The major product formats involve:

- *Cake Product.* Soaps are prepared primarily in this form.
- *Granular Powdered Product.* A significant proportion of laundry detergents are prepared in this form, as well as automatic dishwasher detergents and speciality cleaners, especially abrasive cleaners.
- *Liquid Product.* This is the broadest application format. Soaps, laundry detergents, dish detergents, and specialty cleaners are all prepared in this form.
- *Other Formats.* A variety of specialized formats are employed, including impregnated strips or pads, as well as premeasured pouches.

3.3 GENERIC PROCESSES

Five major generic processes were selected as central to the soap, detergents and related products sector. These are summarized as follows, along with an indication as to whether they represent primary or secondary production operations (as defined in Section 3.2):

- Soap production (primary);
- Surfactant production (primary);
- Cake product formulation (secondary);
- Liquid product formulation (secondary); and
- Granulated powdered product formulation (secondary).

Detailed descriptions of these generic processes are given in Section 3.4. The reasons for selecting these generic process/product combinations are as follows:

- they cover the wide range of product manufacturing activities undertaken;
- they represent the natural groupings of similar generic processes, which exhibit similar resource and environmental residual concerns; and
- generic processes for active ingredients, other than surfactant, are not included, because other active ingredients are not innate to the industry.

Certain limitations must be recognized for this generic characterization of the industry:

- a generic approach assumes a high degree of homogeneity between and among manufacturing processes and resource consumption patterns of different plant operations within a specific sector. Variability, however, occurs between plants, even those that are producing the same products using the same basic processes.
- A generic approach ignores site-specific limitations and considerations. This is particularly important with regard to the implementation of potential improvement technologies. Experience indicates that specific

technologies may provide substantial benefits at one plant, while the same technology may in fact impose net costs at another plant.
- a generic approach must largely ignore the intricacies of specific processes, technologies, and equipment.

As a result, this guide should be used as a starting point for site-specific evaluations in combination with other sources of knowledge and experience related to the soap and detergents manufacturing sector.

3.4 GENERIC PROCESS AND UTILITY DESCRIPTIONS

Generic process descriptions are provided for each of the five major processes. Each of the process descriptions is also presented in the form of a block flow diagram.

- *Soap Production (Exhibit 3.2).* Soap production primarily involves the preparation of carboxylate surfactant from triglycerides, which in turn are derived almost exclusively from natural source materials (e.g. tallow and vegetable oils). From a process perspective, two basic configurations are now predominant, and are presented in Exhibit 3.2 as follows:

  - *Exhibit 3.2 (a) illustrates a direct saponification* approach, in which triglycerides and alkalis are reacted together directly to form soap. This approach is close to traditional preparation methods, and is typically conducted in batch kettle operations for specialized products. In this case, the nature of the product is determined by the blending of various feed ingredients (i.e. the mix of fats, oils and other raw materials).

  - *Exhibit 3.2 (b) illustrates a segregated operations* approach, in which triglyceride hydrolysis, fatty acid fractionation and soap formation processes are separated. This approach is employed in higher volume operations, typically using continuous processes. The final product in this case is determined by the blending of specific fatty acids.

- *Surfactant Production (Exhibit 3.3).* Surfactant manufacturing involves the production of synthetic surfactant from predominantly petrochemical base feedstocks, using the relevant feedstocks as a starting point. An overview process flow schematic showing the nature of feedstock flows is provided in Exhibit 3.3 (a).[8] The primary reactions involved include: sulfonation; sulphation; ethyoxylate; and ester reactions. From a process perspective, two basic configurations are now predominant, and are presented in Exhibit 3.3 as follows:

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[8] Based on Greek, B. 1988. Detergent Components Become Increasingly Diverse, Complex. Chemical & Engineering News. Vol. 66. January 25 Issue. p32.

- *Exhibit 3.3 (b)* illustrates a batch process approach, employed mainly for smaller volume speciality surfactant.

- *Exhibit 3.3 (c)* illustrates a continuous process approach, employed for higher volume surfactant production.

- *Solid Cake Product Formulation (Exhibit 3.4).* Solid cakes are produced almost exclusively for soap-based products, whether for personal or laundry use.

- *Liquid Product Formulation (Exhibit 3.5).* Liquid versions are available for almost all types of soap, detergent and other related products.

- *Granulated Powdered Product Formulation (Exhibit 3.6).* Powders are used primarily for laundry and automatic dishwasher detergent products, as well as various specialized products. From a process perspective, three basic configurations are now predominant. The selection of the process depends on the nature of the products involved.

  - *Exhibit 3.6 (a)* illustrates a process approach based on spray tower.

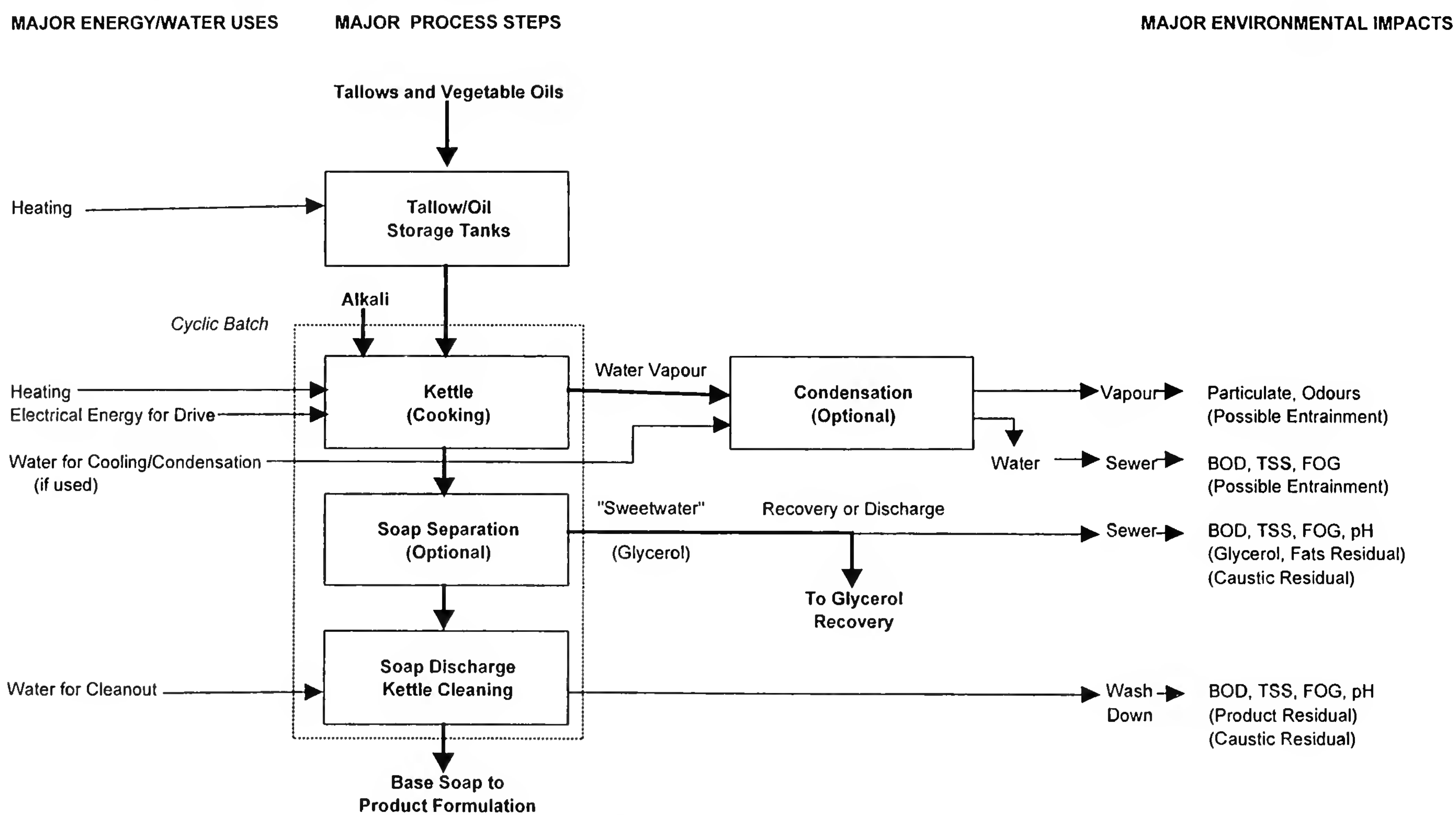
  - *Exhibit 3.6 (b)* illustrates a process approach based on agglomeration.

  - *Exhibit 3.6 (c)* illustrates a process approach based on dry ingredient mixing.

These generic process descriptions include the relevant steps. On the left side of each diagram, high energy and water uses are highlighted at the corresponding step, while major environmental effects are highlighted on the right. The typical utility and service demands for plants overall are summarized in Exhibit 3.7. The importance of the different utilities can vary between processes, as indicated. Utility requirements can also vary between different plants producing the same product.

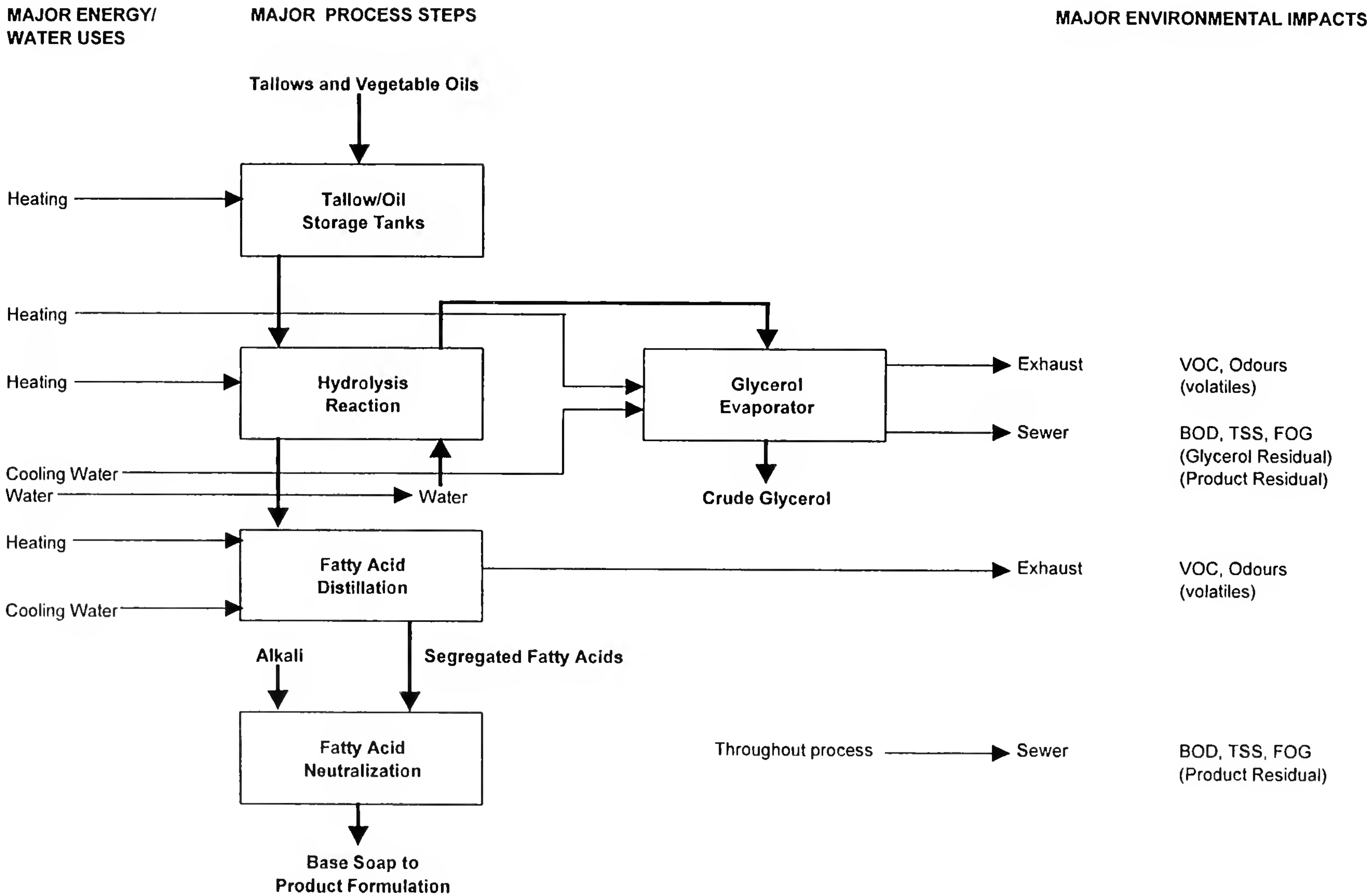
EXHIBIT 3.2: Process Flow Diagram for Soap Production

3.2 (a) Direct Saponification Approach for Soap Production



Refer to Exhibit 7.1 for Improvement Opportunities

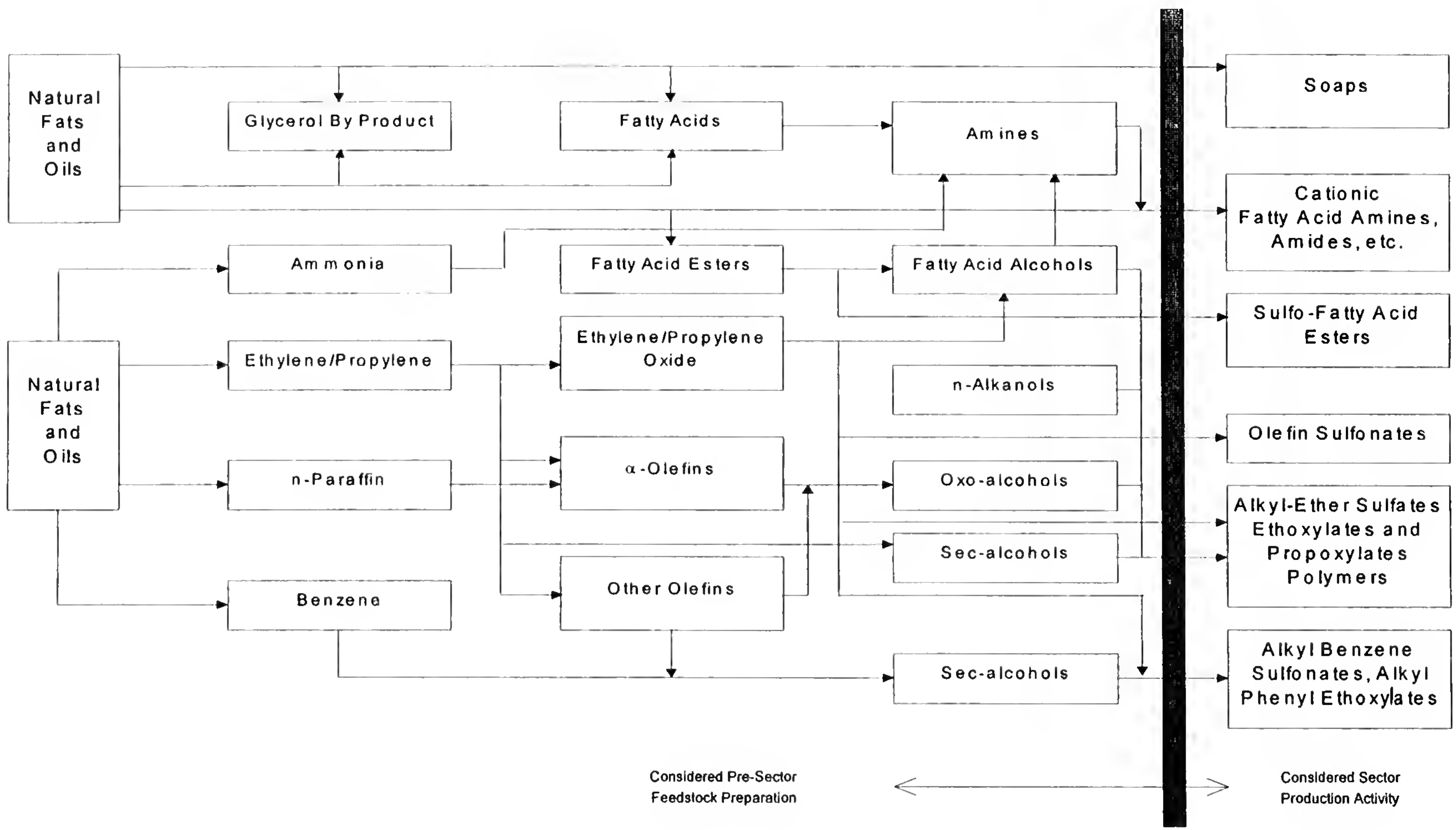
3.2 (b) Segregated Operations Approach for Soap Production



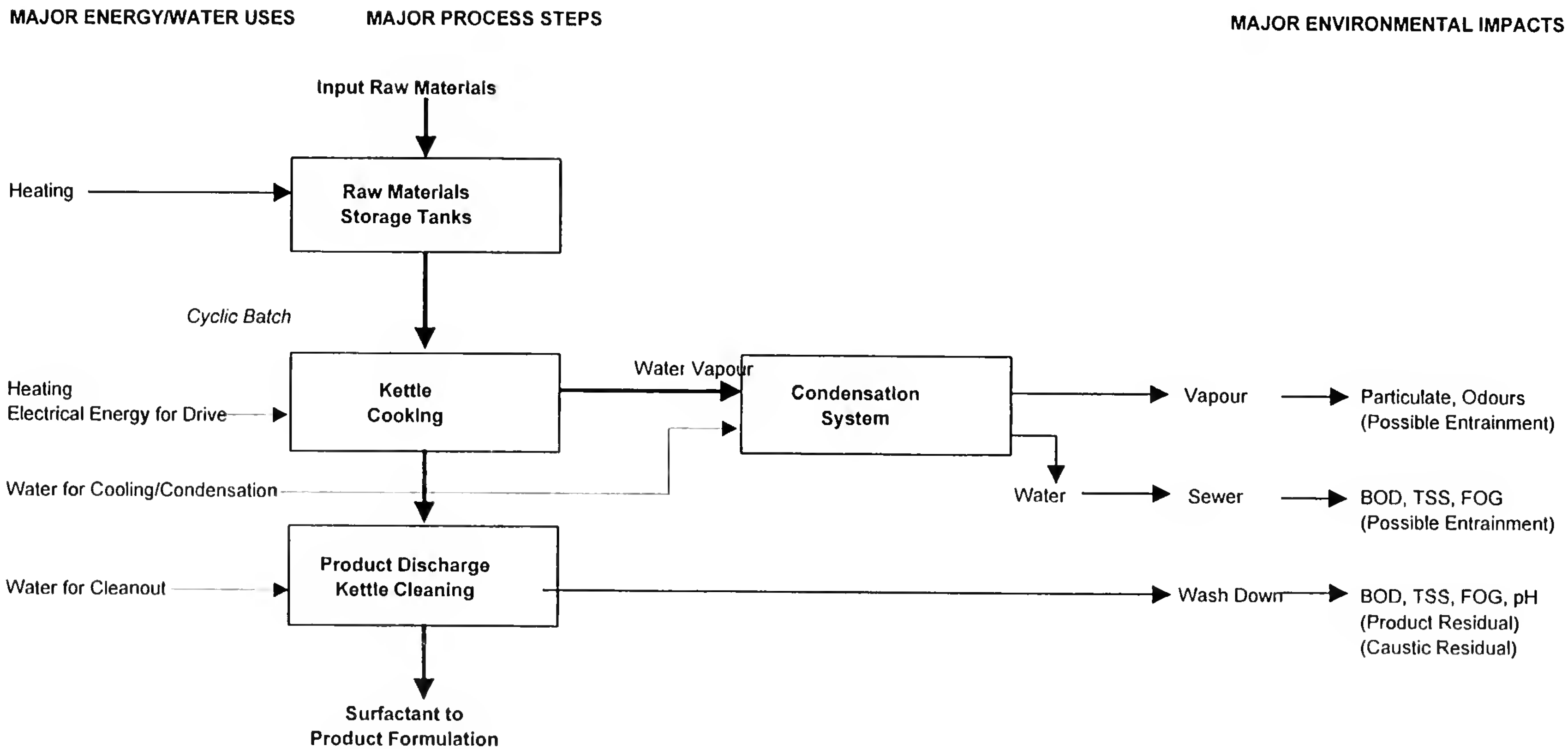
Refer to Exhibit 7.1 for Improvement Opportunities

EXHIBIT 3.3: Process Flow Diagram for Surfactant Production

3.3 (a) Synthetic Petrochemical Feedstock Flow to Surfactant Manufacturing

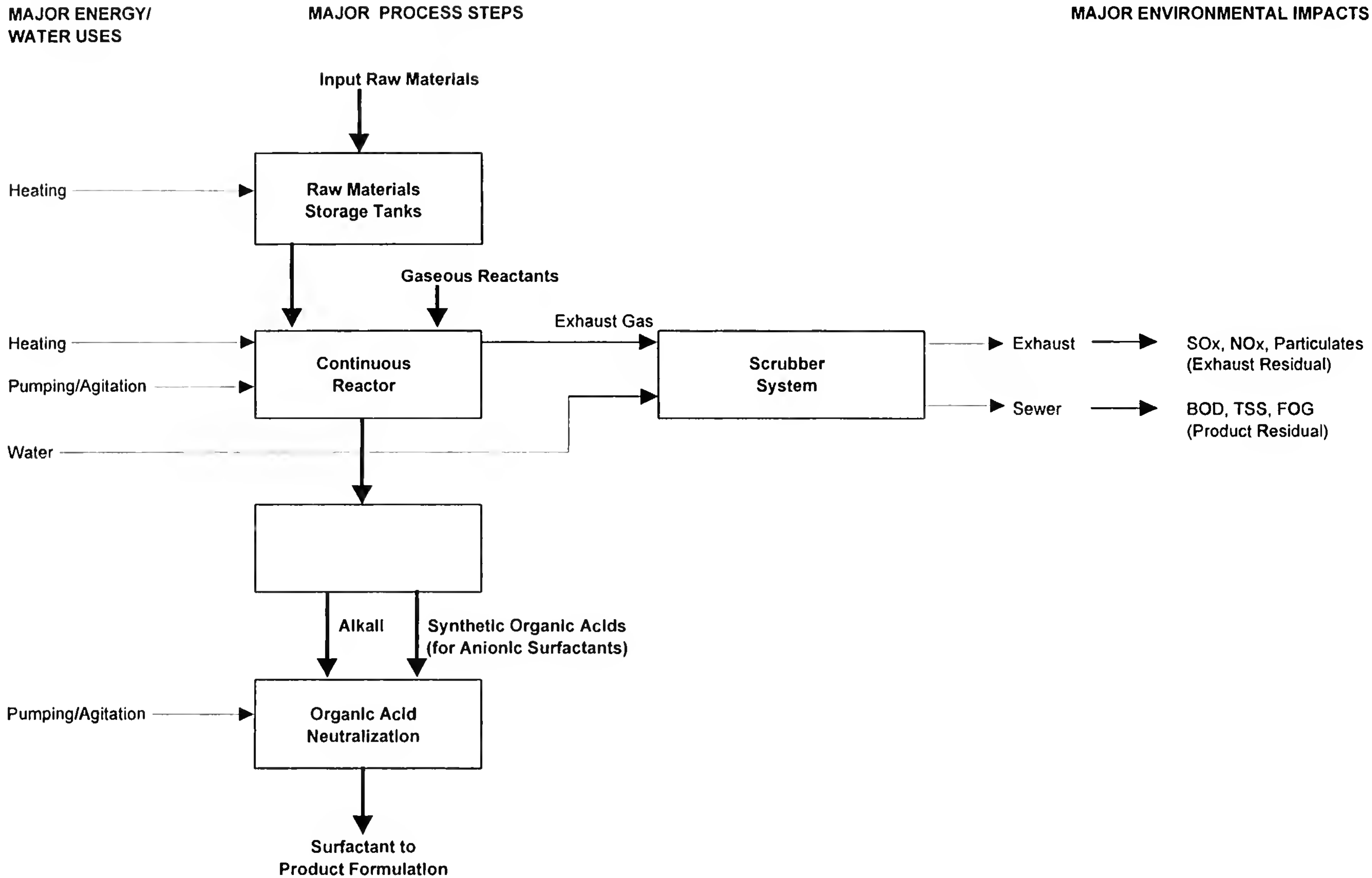


3.3 (b) Batch Specialty Surfactant Production



Refer to Exhibit 7.2 for Improvement Opportunities

3.3 (c) *Continuous Surfactant Production*



Refer to Exhibit 7.2 for Improvement Opportunities

EXHIBIT 3.4: Process Flow Diagram for Solid Cake Product Formulation

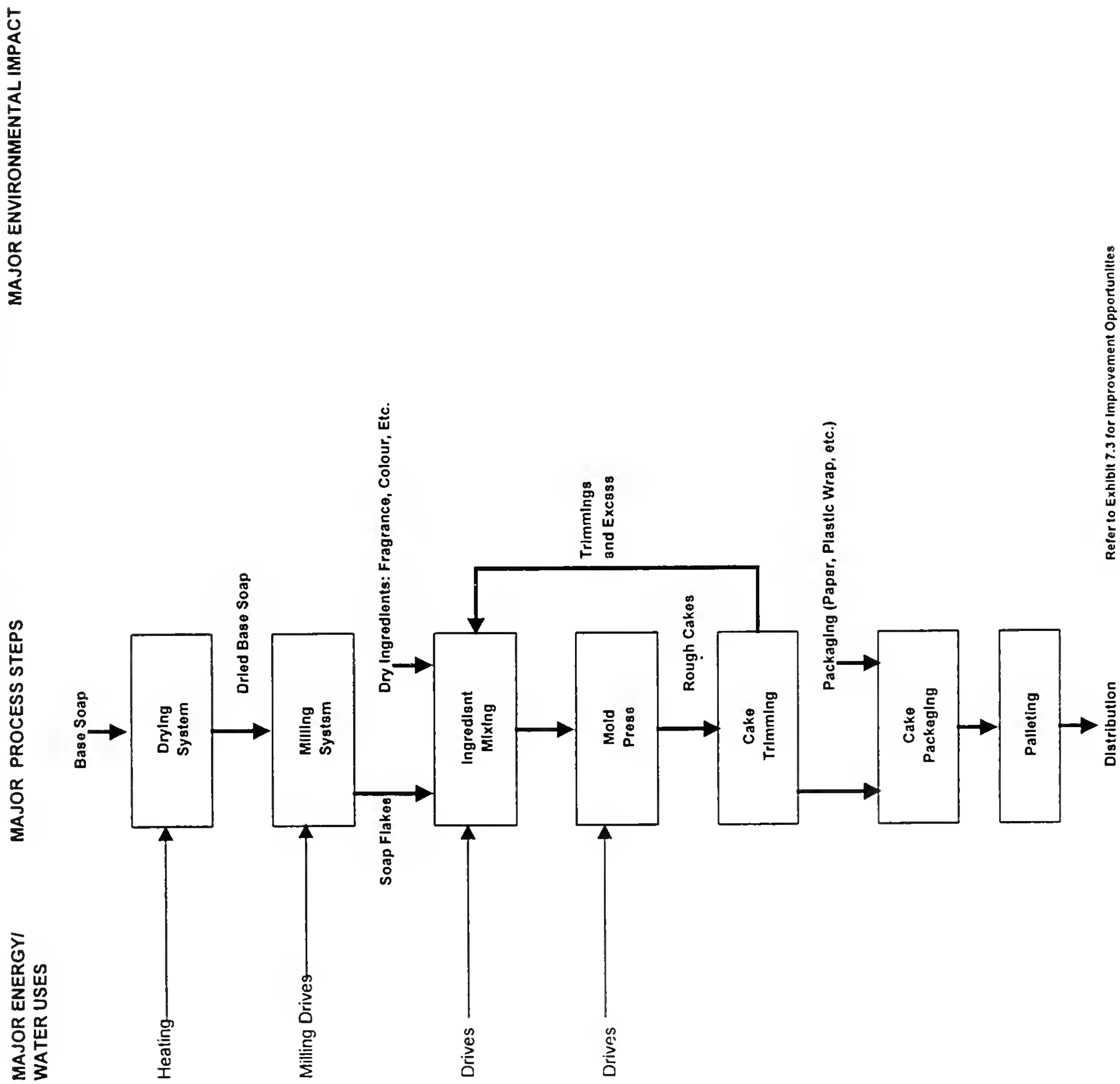
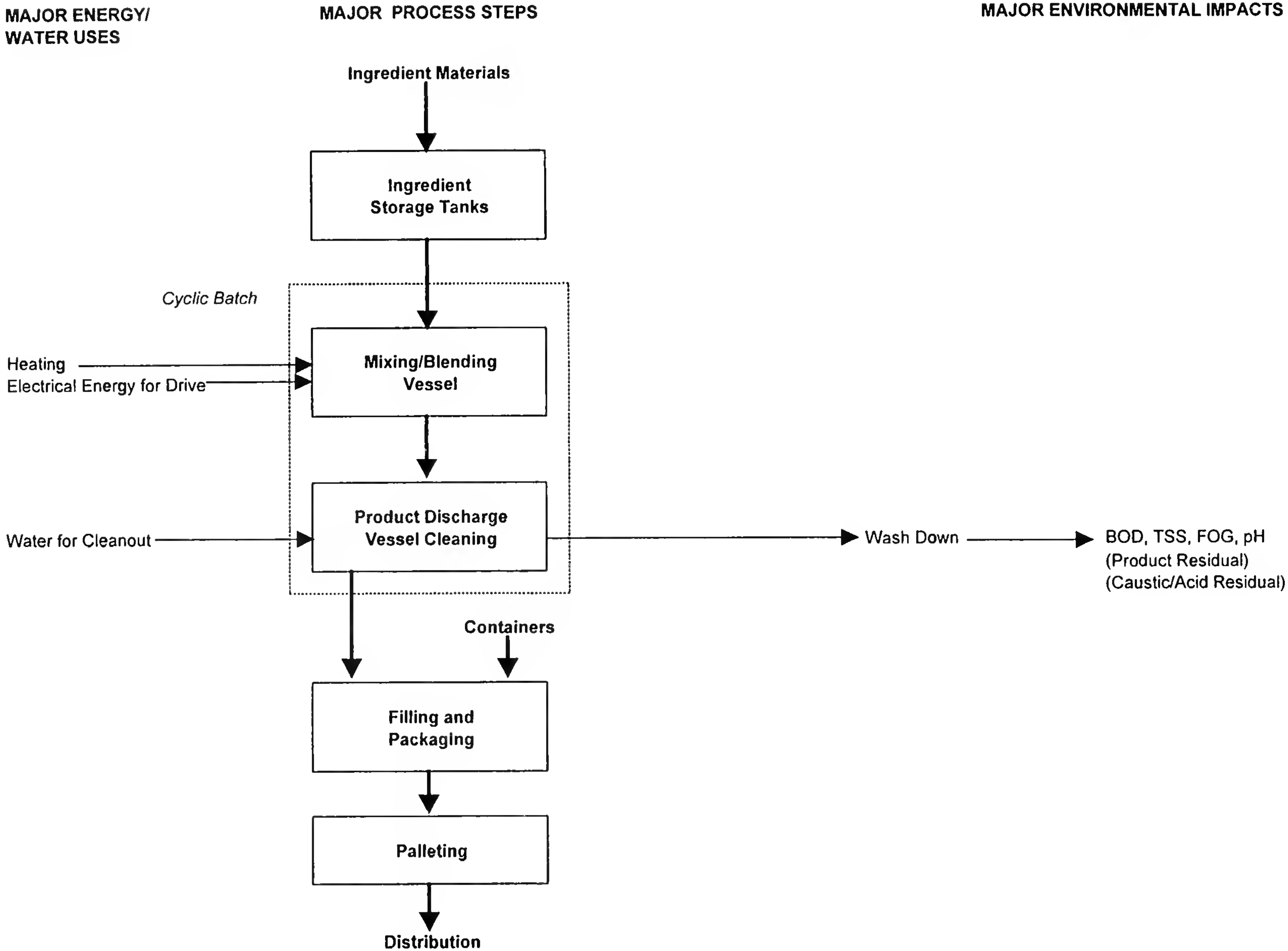


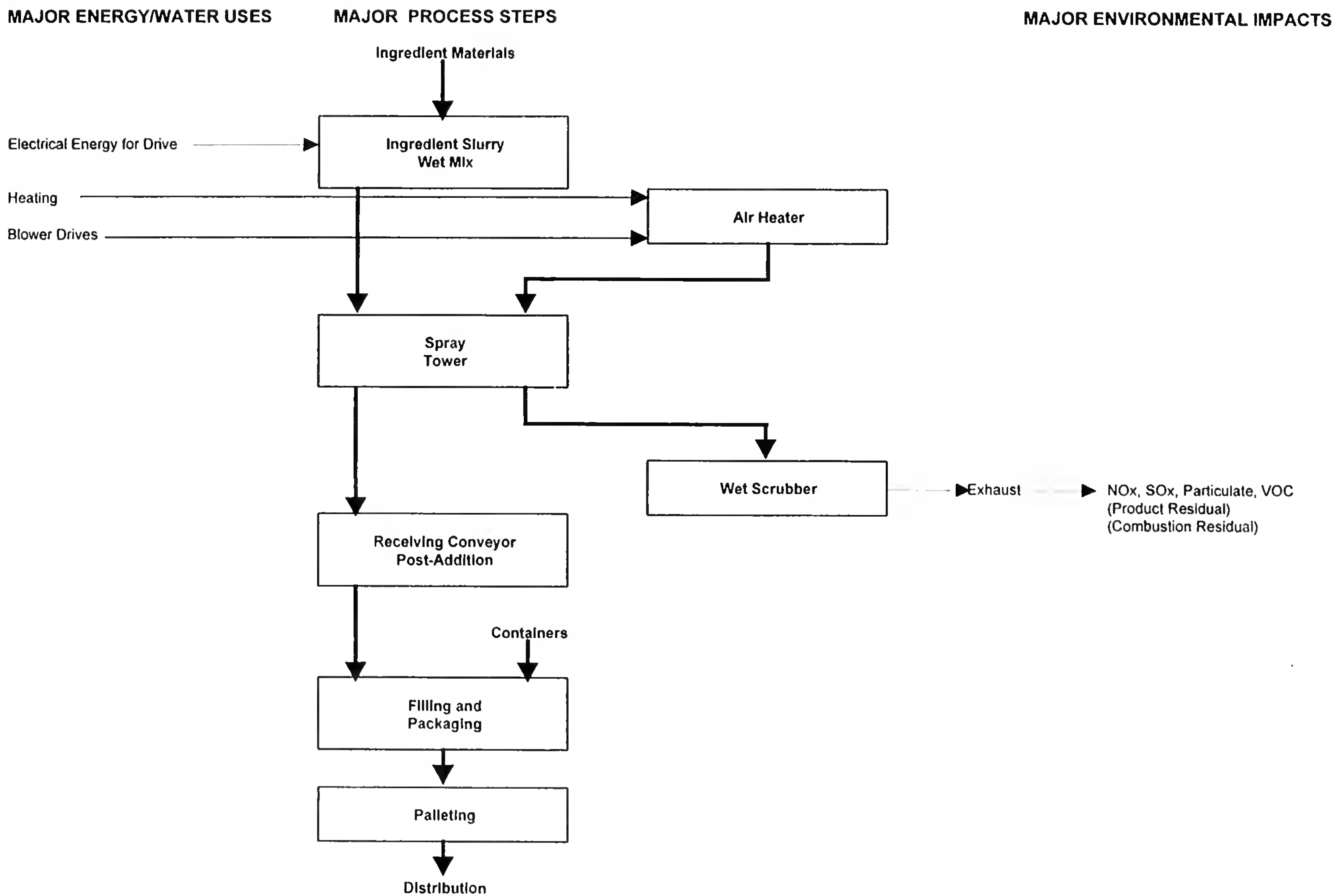
EXHIBIT 3.5: Liquid Product Formulation



Refer to Exhibit 7.4 for Improvement Opportunities

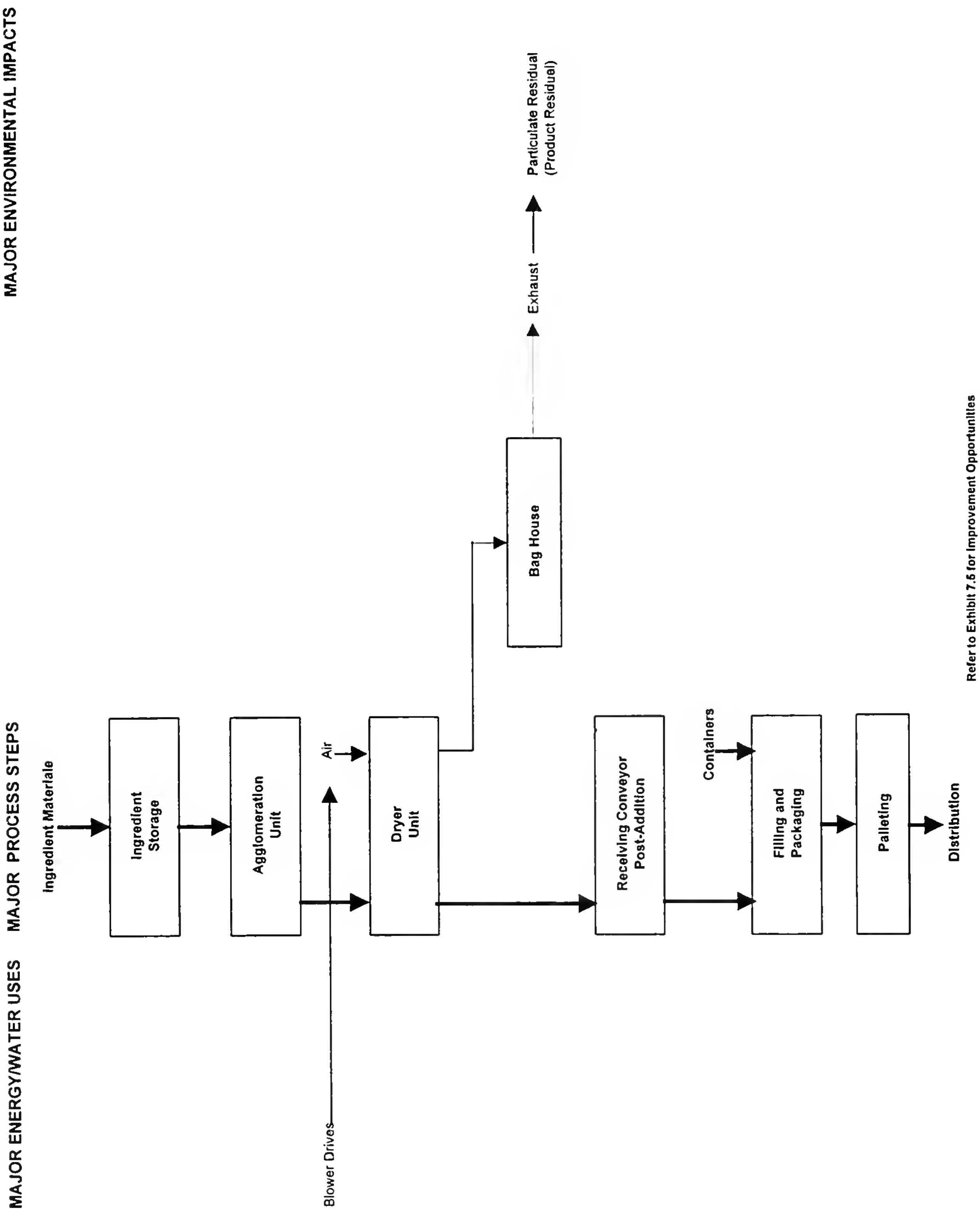
EXHIBIT 3.6: Granulated Powdered Product Formulation

3.6 (a) Spray Tower-based Process



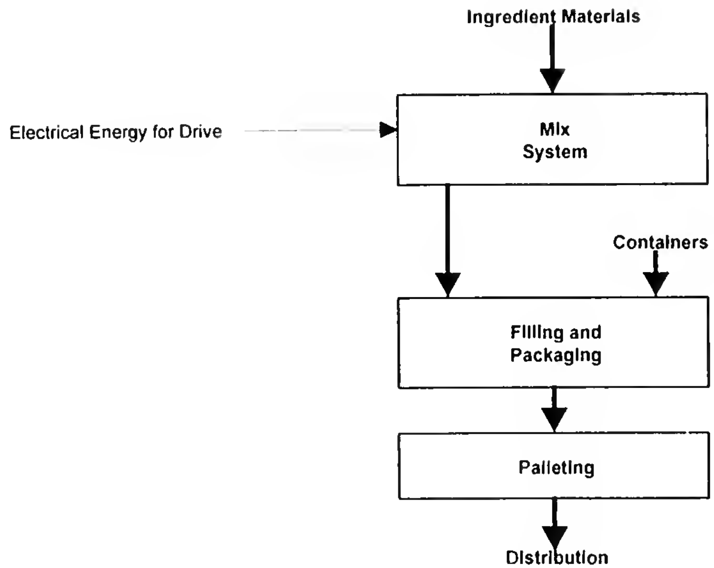
Refer to Exhibit 7.5 for Improvement Opportunities

3.6 (b) *Agglomeration-based Process*



3.6 (c) Dry Mix-based Process

MAJOR ENERGY/WATER USES | **MAJOR PROCESS STEPS** | **MAJOR ENVIRONMENTAL IMPACTS**



Refer to Exhibit 7.5 for Improvement Opportunities

EXHIBIT 3.7: Typical Utility and Service Requirements

UTILITY	DEMAND REQUIREMENTS	SPECIFIC PROCESS
Cold Water: 10°C City	Rinsing, Washing Recirculation Cooling	Soap, Surfactant, and Liquid Product Formulation Soap and Surfactant
Hot Water: 50+°C	Washout	Batch - Soap, Surfactant, and Liquid Product Formulation
Steam: High Pressure Low Pressure	High Temperature Soap Reactions Spray Drying Surfactant Reactions	Soap Powdered Product Surfactant
Natural Gas: Furnace Boiler Heater	Space Heating Hot Water/Space Air Heating	All All Powdered Product
Compressed Air	Air Blows, Conveying	All
Electrical (Direct Uses)	Conveyors, Pumps Agitators, Packaging Unit Drives, Lights	All

4.0 RESOURCE UTILIZATION

Soap, detergents and related products processing, in general, can be described as not highly intensive with regard to energy or water, but quite highly intensive with regard to input raw materials. This characteristic of the industry is demonstrated by the following breakdown of 1994 operational cost data for four SIC categories in which establishments may be classified:[9]

SECTOR	PROPORTION OF 1994 OPERATIONAL COSTS		
	Fuel and Electricity	Materials and Supplies	Wages and Salaries
Soap and Cleaners (SIC 3761)	1.7%	68.7%	29.6%
Toilet Preparations (SIC 3771)	1.0%	56.4%	42.6%
Organic Chemicals (SIC 3712)	8.1%	81.4%	10.5%
Other Chemicals (SIC 3799)	2.9%	74.2%	22.9%

Specific resource use by soap, detergents and related products processing plants is summarized in more detail in the following sections.

4.1 ENERGY

Energy usage and associated costs are generally well monitored, and well understood by individual plants. Two forms of energy are primarily employed in Ontario plants:

- Electricity, primarily for various drives; and
- Natural gas, primarily for process and space heating (thermal) requirements.[10]

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9 Data from Strategies at: http://www.strategis.ic.gc.ca for SIC's 3761, 3771, 3712 and 3799.

10 Energy data for SIC 3761 for the period from 1990 to 1994 indicates that light fuel oil, heavy fuel oil, and liquefied petroleum gases represent on average less than 2% of thermal energy utilization within Ontario.

Total energy use statistics for all plants classified within SIC 3761 for Ontario and Canada for the years 1990 through 1994 are presented in Exhibit 4.1.[11] Over this time period, Ontario plants have consistently represented approximately 80% of overall electrical energy-use and approximately 90% of overall thermal energy-use relative to Canada as a whole. This information makes sense given the relative concentration of the industry within Ontario, as described in Section 2.0 and Appendix II. Also, for both Ontario and Canadian aggregate data, overall electrical energy-use has remained relatively constant, while overall thermal energy-use has progressively declined (by approximately 35%) over the five year period presented.

Using overall **Canadian** data for both energy-use and the number of manufacturing establishments, calculated aggregate average energy-use values per establishment are presented in Exhibit 4.2 for the years 1990 through 1994. As can be seen from this exhibit:

- Average total annual electrical energy-use per establishment has been increasing slowly but steadily, from approximately 1.1 million kWh in 1990 to approximately 1.4 million kWh in 1994; while
- Average total annual thermal energy-use per establishment has been declining, from approximately 16 million MJ to approximately 13 million MJ.

An approximate average breakdown of energy costs by type, based on **Ontario** data, is presented in Exhibit 4.3. The values presented have remained fairly constant over the period of 1990 to 1994. As can be seen, electricity is by far the largest cost component, representing more than 50% of energy costs on average.

Unfortunately, there is no convenient, readily available production unit for the soap, detergents and related products industry that can be used to determine aggregate energy-intensity. Therefore, industry manufacturing shipments values available from Statistics Canada for the SIC 3761 have been used to evaluate energy intensity, with data developed as follows:

- Electrical and thermal energy content intensities of products are presented for the years 1990 through 1994 in Exhibit 4.4 (in units of kWh and kJ per $ Manufacturing Shipments respectively).
- Electrical, thermal, other fuel, and total energy cost intensities of products is presented for the years 1990 through 1994 in Exhibit 4.5 (in units of $ per $ Manufacturing Shipments).

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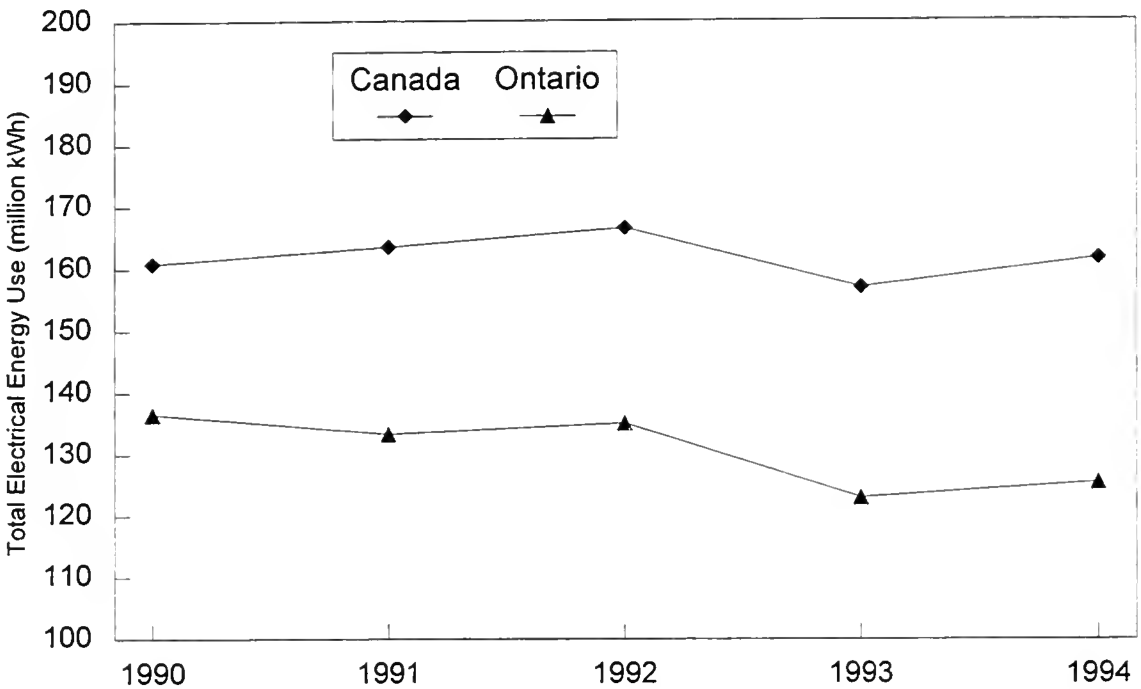
11 Data from Nyboer, J. et al., Canadian Industry Energy End-use Database and Analysis Centre. 1997. Simon Fraser University.

EXHIBIT 4.1: Historical Energy-Use Data for SIC 3761 (Soap and Cleaners)

Total Aggregate Electrical Energy-Use for Sector within Ontario and Canada



Total Aggregate Thermal Energy-Use for Sector within Ontario and Canada

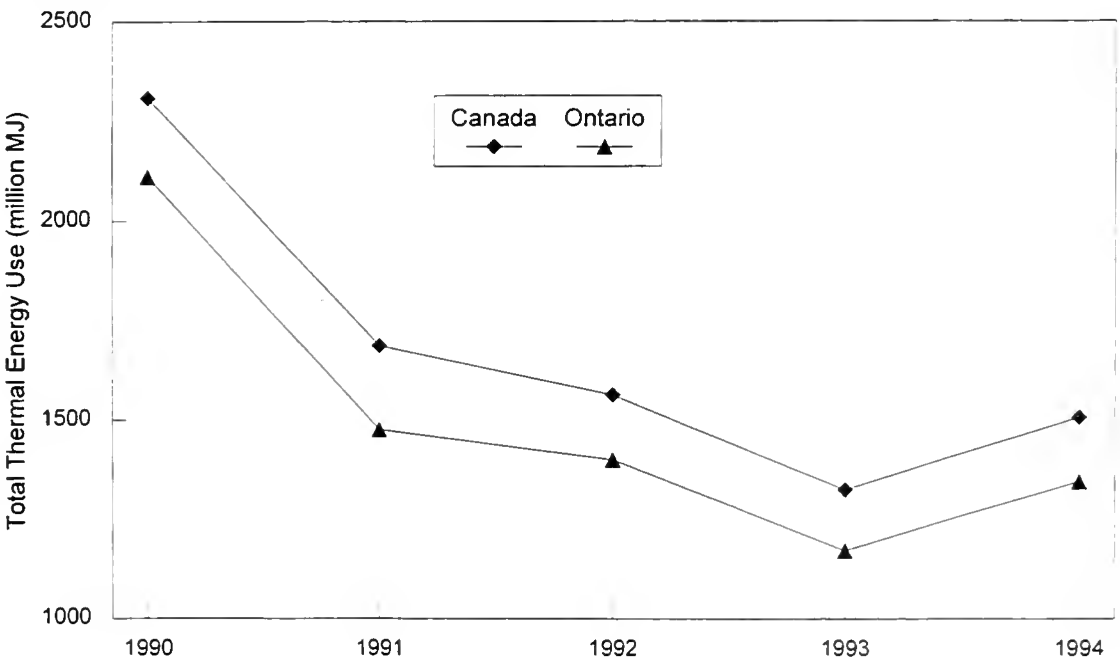


EXHIBIT 4.2: Average Annual Energy-Use per Establishment (Canadian Data)

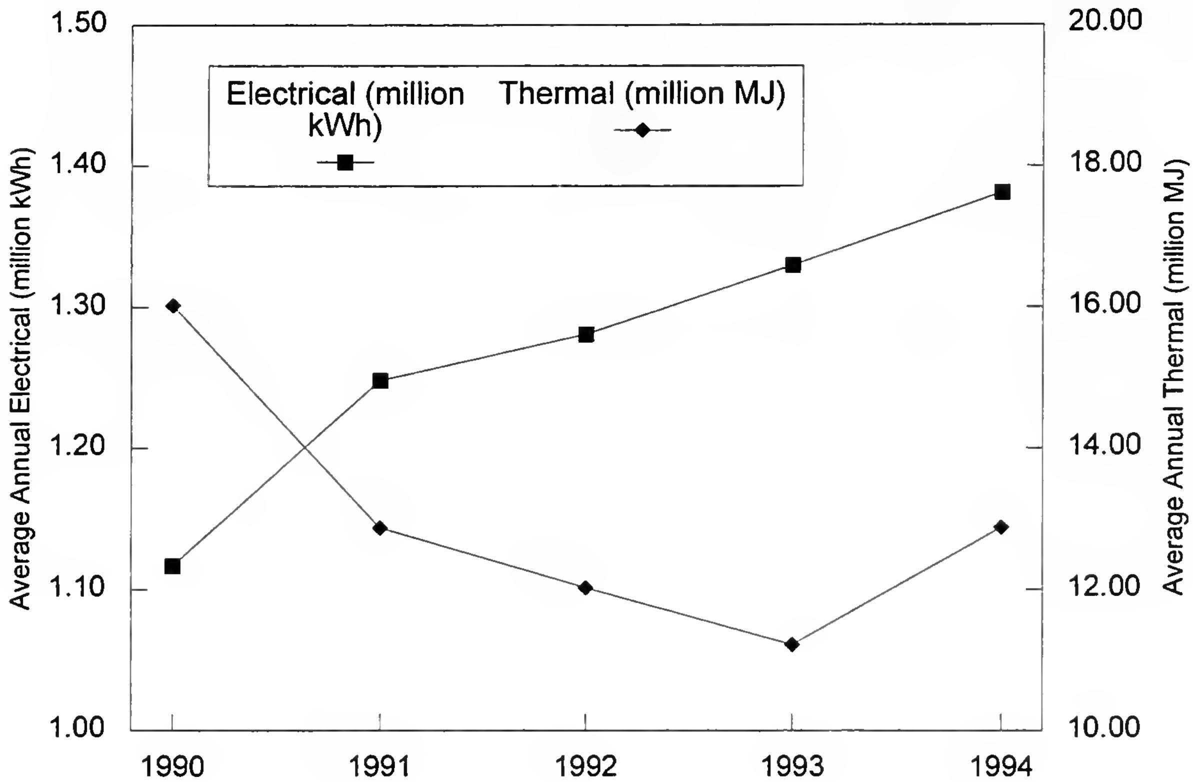


EXHIBIT 4.3: Average Breakdown of Energy Costs in Ontario by Type

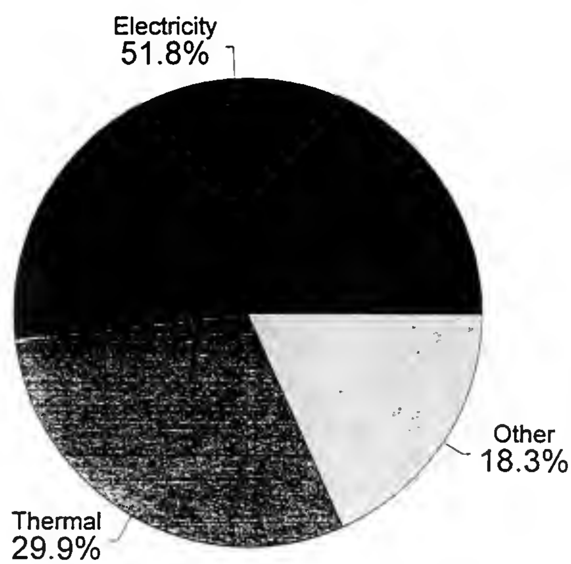


EXHIBIT 4.4: Energy Content Intensity (Canadian Data for SIC 3761)

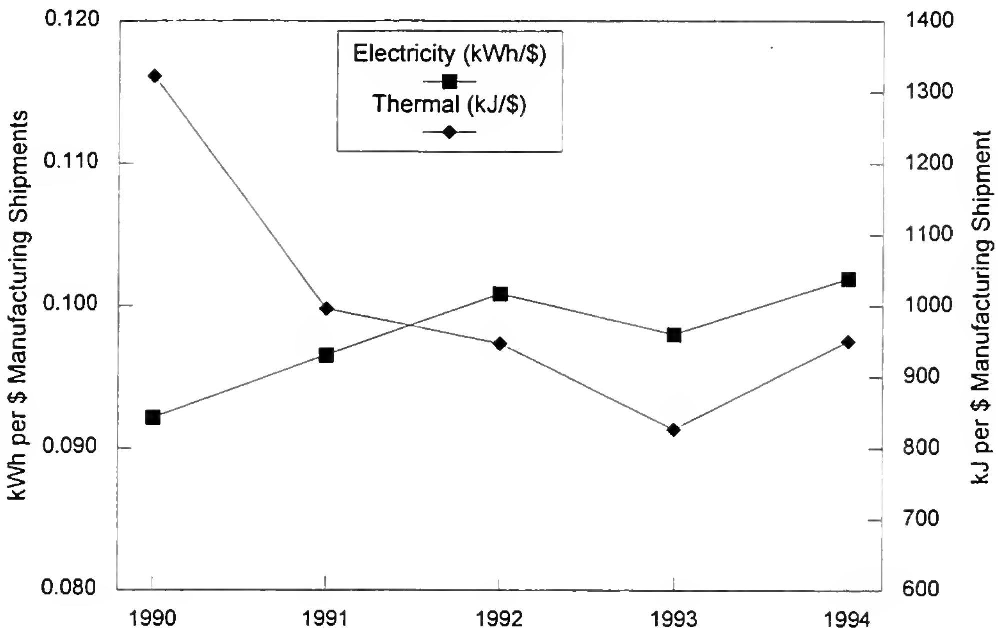
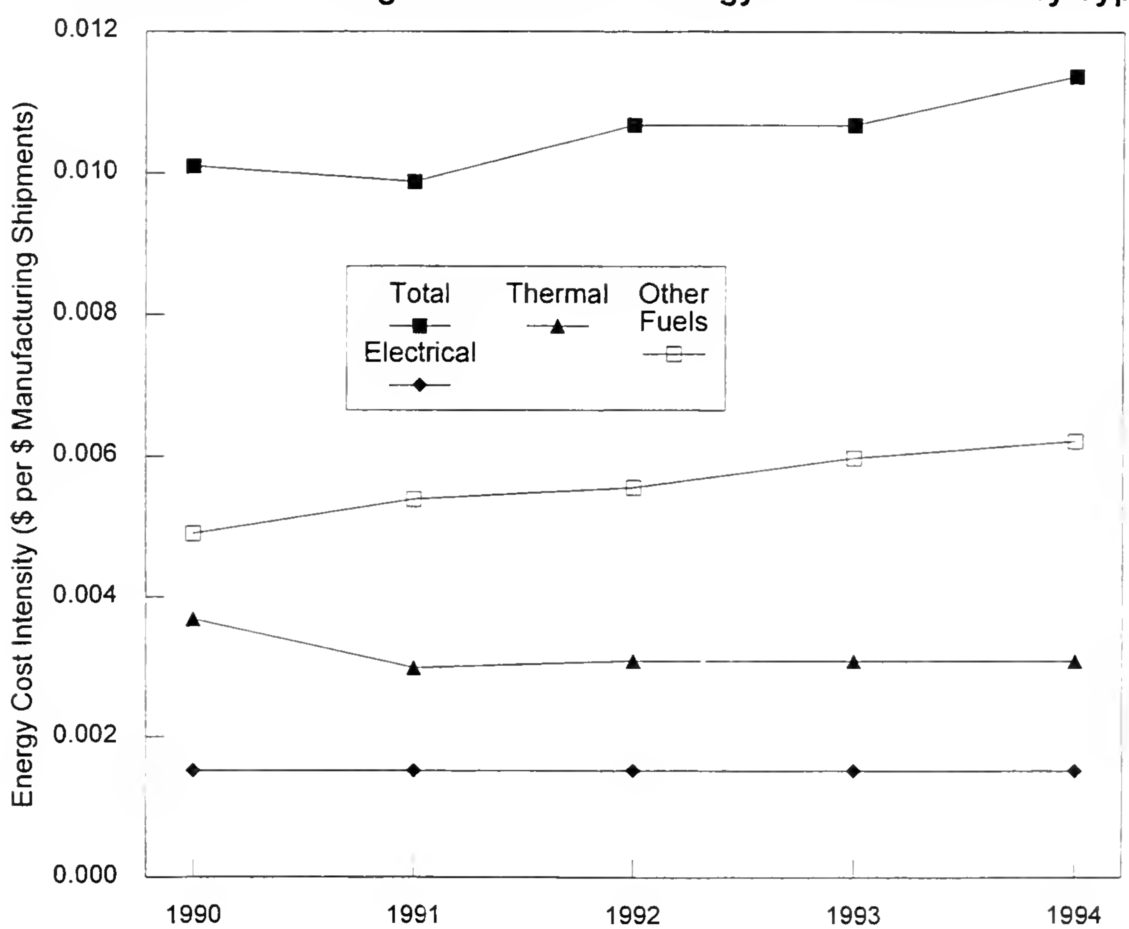


EXHIBIT 4.5: Average Breakdown of Energy Costs in Ontario by Type



Over the period presented, electrical intensity has been increasing steadily, both in terms of energy units and costs. At the same time, thermal intensity has been generally declining, both in terms of energy units and costs. Overall, an increase in energy cost intensity is observed in Exhibit 4.5 from 1990 through 1994. However, the energy cost intensity of the sector is still relatively low, when compared to other manufacturing industries.

4.2 WATER USE

Water use within processing plants in Ontario is not well documented. The lack of accurate data is due in part to the typically low cost associated with this resource in the past, and its frequent treatment as a fixed or overhead cost, rather than a variable manufacturing cost. Within this sector, water use is highly variable, although generally, use is higher in primary active ingredient production than in secondary product formulation.

Environment Canada has been tabulating industrial water-use data on a five year cycle, with data currently available for 1981, 1986 and 1991. It is currently collecting water-use data for 1996. However, this information was not available prior to publication of this guide. A generic view of industrial water-use, as employed by Environment Canada, is presented in Exhibit 4.6.[12]

Aggregate average water-use per establishment is presented in Exhibit 4.7, based on Environment Canada data, both for soap and cleaners (SIC 3761), and the overall chemical industry for comparison (SIC 37). As can be seen, average water-use per establishment in the soap and cleaners sector has been approximately one tenth of that of the broader chemical industry. While average water-use has been dropping significantly for the overall chemical industry, it has been increasing slightly over time for the soap and cleaners sector.

Although the available aggregate water-use information is from 1991 , it does provide some useful insights for the specific target sector (SIC 3761). An overview of past Environment Canada data is provided as follows:

- Ontario plants account for 90% to 95% of total national net water intake for SIC 3761, again confirming the concentration of the industry within Ontario.
- Approximately 20% of Gross Use is Recycled, with the remaining 80% being Intake. The proportion of water recycling in the sector is lower than the overall chemical industry.
- Average water-use (Intake) per establishment is approximately 150,000 m^3 annually.
- Average net effluent discharge volume (Total Water Discharge) per establishment is approximately 135,000 m^3 annually.

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12 Tate, D.M. and D.N. Scharf, Environment Canada. 1995. Water Use in Canadian Industry. Social Science Series No. 31.

EXHIBIT 4.6: Generic View of Industrial Water-Use

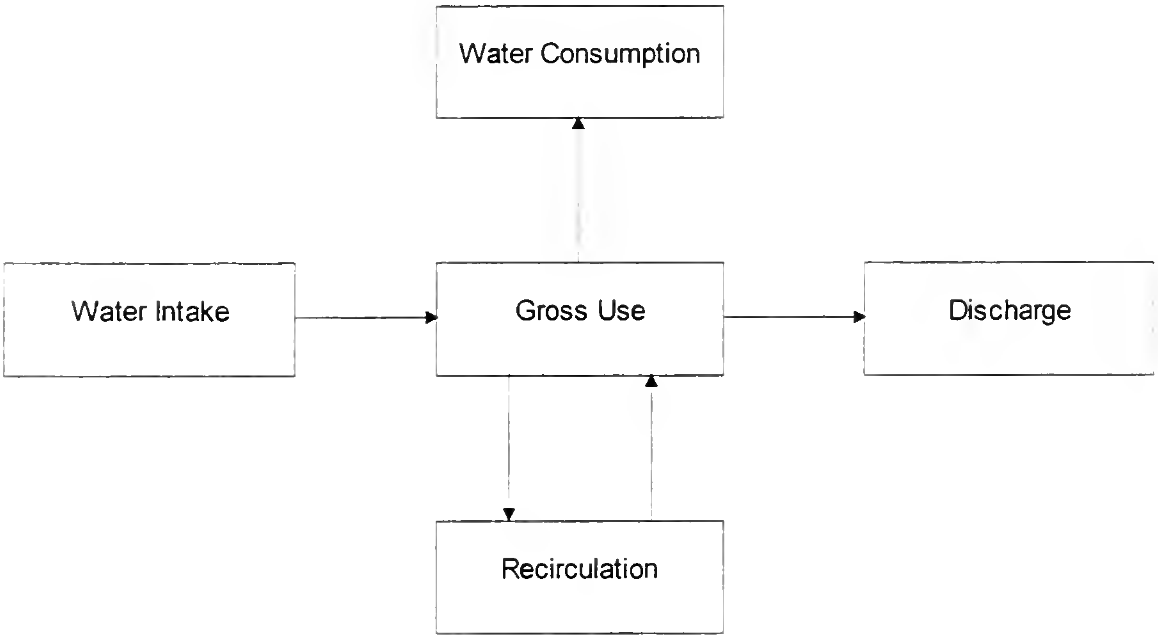
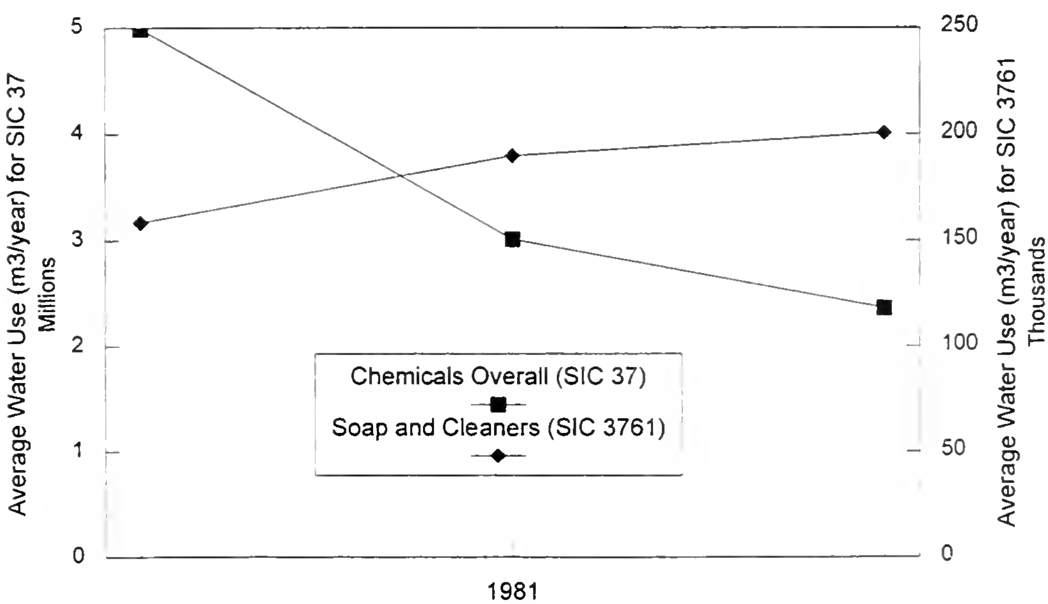


EXHIBIT 4.7: Average Water Use per Establishment
Soap and Cleaners (SIC 3761) and Overall Chemical Industry (SIC 37)



- Majority of Intake water (80% to 85%) is for energy related applications, including cooling, condensing and steam production. A smaller portion (10% to 15%) is used directly in processing.

The collection of improved water-use statistics is desirable for bench marking purposes.

The cost of water varies from municipality to municipality. Water-related charges by municipalities are typically broken into three components, as follows:

- Fresh water supply charge;
- Regular sewerage charge, when effluent water is discharged to a municipal sanitary sewer system; and
- Additional effluent surcharge based on effluent loading (i.e. effluent water flow x excess concentration of effluent parameter(s) above by-law limit), when discharged to a municipal sanitary sewer system.

The last component, the effluent surcharge, is intended to cover specified effluent parameters, and is discussed in more detail in the next section. However, an effluent surcharge is typically based on the discharge effluent flow volume. Metered water in-flow is often used to determine volumes for both feed water and effluent discharge.

Charges for water, including both fresh water and regular sewerage charges, in major Ontario municipalities range from approximately $0.40 to $0.90 per m^3. (Surcharge costs are considered separately.)

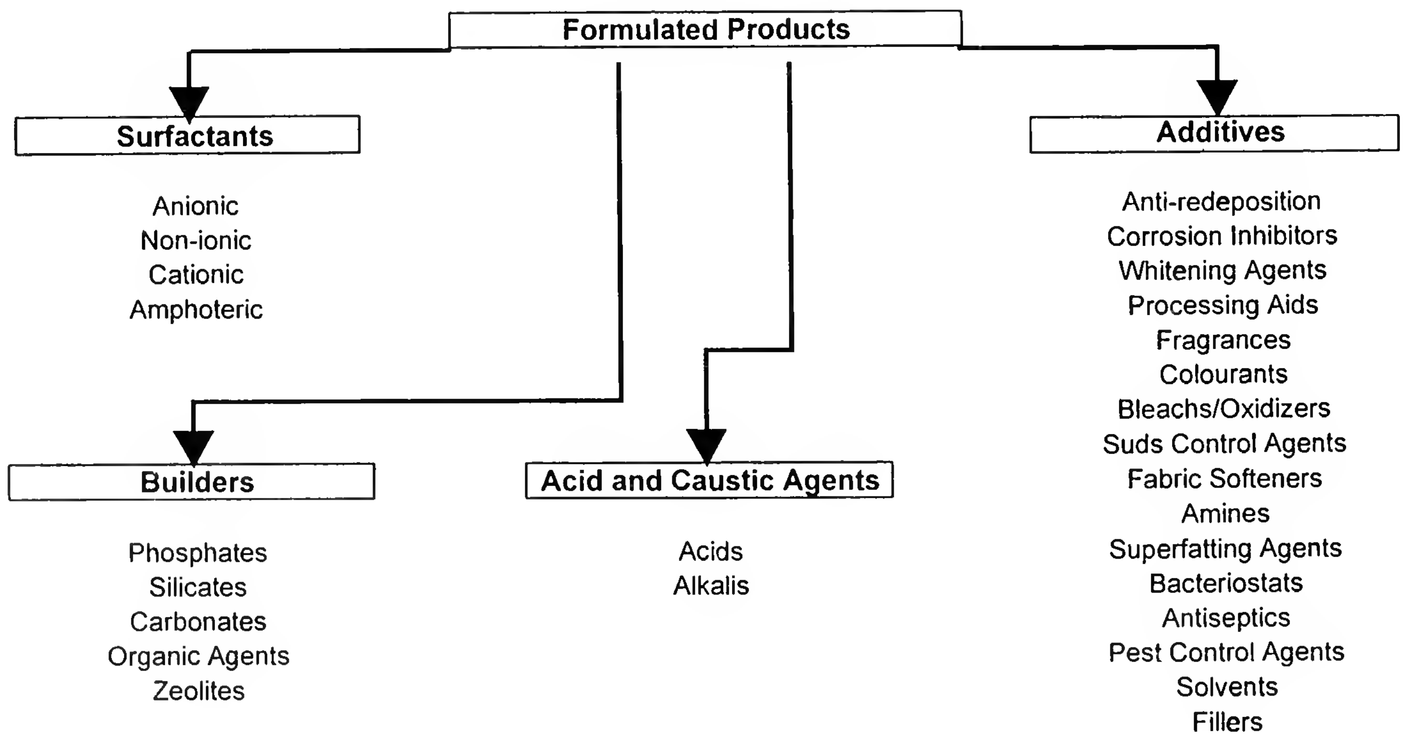
4.3 MAJOR PRODUCT INGREDIENT CATEGORIES

Soap, detergent and related products manufacturing has a relatively high intensity in terms of raw material inputs. The products of the sector can range from relatively simple to very complicated chemical formulations. As illustrated in Exhibit 4.8, there are four major categories of ingredients involved in specific product formulations. The major categories of ingredients are:

- Surfactants;
- Builders or Sequestering Agents;
- Other Additives; and
- Acid and Caustic Agents.

Each of these major categories is described in more detail in Appendix III.

EXHIBIT 4.8: Breakdown of Formulated Products by Ingredient Type



5.0 BENCH MARKING

Bench marking describes a means for business operations to assess their performance relative to their own past and relative to other operations. For bench marking the performance of plants in reducing energy and water use, and effluent discharges, the use of unit performance ratios is highly useful. A series of these ratios is presented in the following sections.

The logical denominator for the ratios is units of production (e.g. kg). However, as noted in Section 4.1, there is unfortunately no convenient, readily available product unit data that would allow the development of aggregate industry information. As such, the ratios are most useful for internal comparison and tracking of progress. The ratios are structured to provide valid assessment, but at the same time to maintain confidentiality, if the collection of broader, comparative data is done on an industry wide basis in the future.

5.1 UNIT ELECTRICAL ENERGY USE

This unit performance ratio would be calculated using the following formula, and reported in units of kWh per kg of product:

$$\text{it Electrical Energy Use} = \frac{\text{Total kWh Electricity Used Over 12 Month Period}}{\text{Total kg Product Manufactured Over Same 12 Mont}}$$

5.2 UNIT NATURAL GAS ENERGY USE

This unit performance ratio would be calculated using the following formula, and reported in units of MJ per kg of product:

$$\text{t NG Energy Use} = \frac{\text{Total } m^3 \text{ Natural Gas Used Over 12 Month Period} \times 37.2\ MJ\,/}{\text{Total kg Product Manusctured Over Same 12 Months}}$$

5.3

Unit Water Use

This unit performance ratio would be calculated using the following formula, and reported in units of Litres of water per kg of product:

$$\text{Unit Water Use} = \frac{\text{Total } m^3 \text{ Water Used Over 12 Month Period} \times 1{,}000\ L\,/\,m^3}{\text{Total kg Product Manufactured Over Same 12 Months}}$$

5.4 UNIT BOD GENERATION

This unit performance ratio would be calculated using the following formula, and reported in units of mg BOD per kg of product:

$$Unit\ BOD = \frac{Avg.\ mg\ /\ L\ BOD_5 \times 1{,}000\ L\ /\ m^3\ /\ yr\ Effluent\ Volume}{Total\ kg\ Product\ Manufactured\ Over\ Same\ 12\ Months}$$

5.5 PRODUCT LOSS TO EFFLUENT

Given the relatively close relationship between BOD generation and product concentration, as described in Section 6.1.3, this unit performance ratio can be used to develop an effluent product loss ratio, as follows:

$$Effluent\ Product\ Loss(\%) \approx \frac{Unit\ BOD\ Generation\ (mg\ /\ kg) \times 100\%}{1{,}000{,}000\ mg\ /\ kg}$$

6.0 PROCESS RESIDUALS

The importance of resource consumption and residual impacts can be visualized using a generic model of environmental effects of industrial processes, as presented in Exhibit 6.1. Two types of residuals result from any given industrial operation, process-associated residuals and product-associated residuals.

A key observation, based on the model, is that the residual effects overall for soap, detergents and related products tend to be overwhelmingly downstream-loaded, specifically in the form of water-borne product residuals. The intended use of the products is for cleaning, and, as such, the majority of the products will end up ultimately in domestic, institutional or industrial effluents.

The important residuals associated with soap, detergents and related products manufacturing are outlined in the following sections.

6.1 WATER-BORNE RESIDUALS (WASTE-WATER)

Soap, detergents and related products manufacturing can generate liquid effluents and effluent loadings.

6.1.1 Effluent Discharge Alternatives

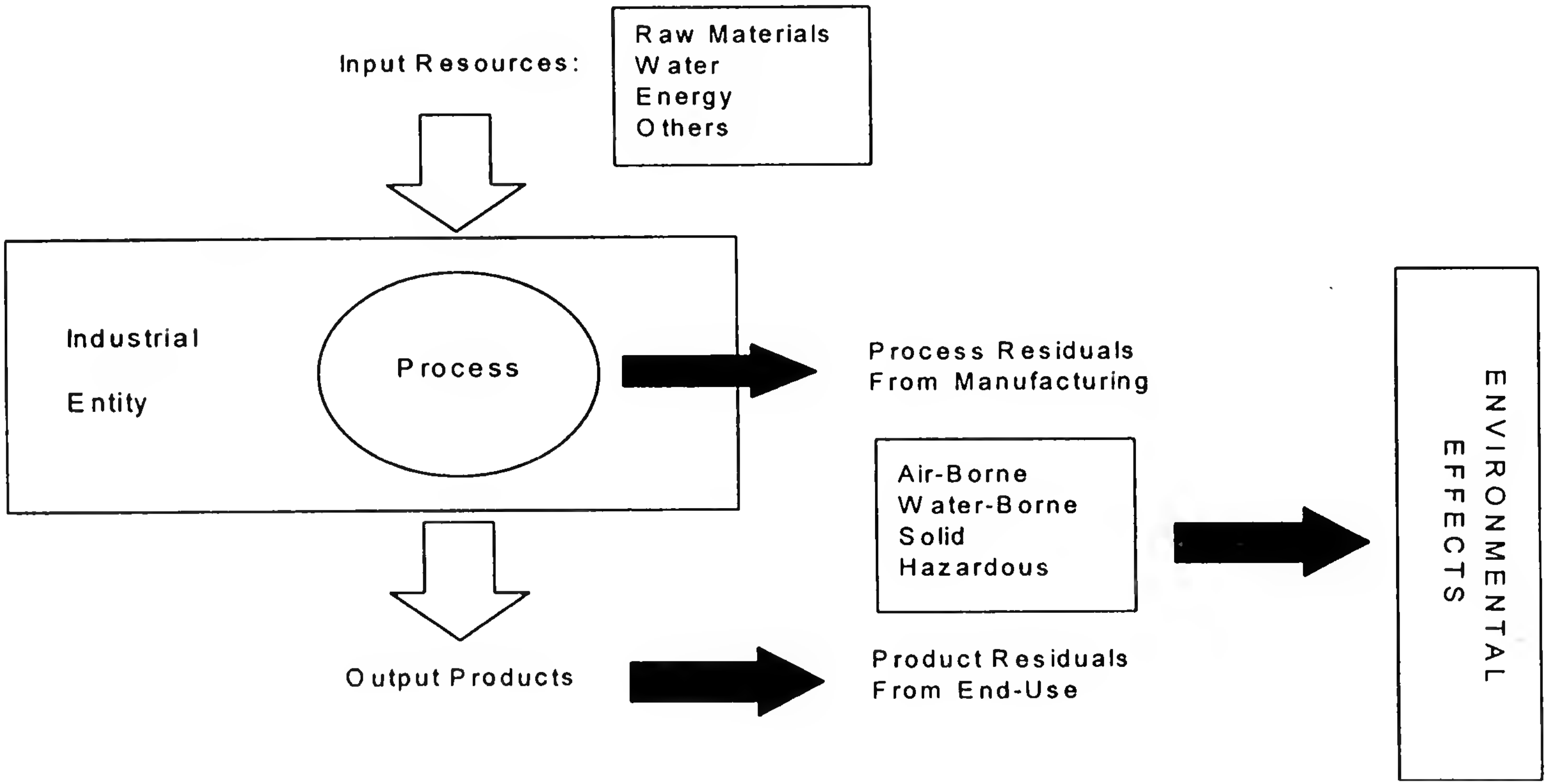
A number of effluent discharge alternatives are used by processing plants in Ontario, as summarized in Exhibit 6.2. The first major distinction in effluent management is whether or not a plant discharges to a municipal sewer system. Those plants involving direct discharge to a surface water receiving stream, fall under the regulatory requirements of Ontario environmental legislation and typically must incorporate on-site treatment in a Private Sewage Treatment system (PST). There are only a relatively small number of plants within the target sector in this category.

Plants discharging to a municipal system have a number of further alternatives, illustrated in Exhibit 6.2:

- they may choose to treat effluent in the plant prior to discharge. In this case treatment for control of pH, reduction of fats, oils and greases, and/or biological oxygen demand (BOD) are most common.
- they may provide a capital contribution or pay charges to the municipal treatment system.

Municipal dischargers may also be subject to a sewer surcharge for excess discharge of certain parameters such as BOD, total suspended solids and phosphorus.

EXHIBIT 6.1: Generic Model of Environmental Effects of Industrial Processes



6.1.2 Effluent Loading Parameters, Sources and Effects

The major regulated effluent parameters of concern to processing plants include the following:

- Biological oxygen demand (five day) or BOD_5, which measures the oxygen required to biologically consume organic in an effluent flow;
- Total suspended solids (TSS);
- Solvent-extractable matter of mineral origin, and of animal or vegetable origin, often termed Fats, Oil and Grease (FOG);
- Phosphorus, usually measured and expressed as total phosphorus (TP);
- Nitrogen, including constituents such as ammonium-nitrogen and total Kjeldahl nitrogen (TKN); and
- pH, which measures levels of acidity or alkalinity of the effluent flow.

Compounds within soap, detergent and related product formulations can have deleterious effects on municipal sewage collection and wastewater treatment systems. A summary of identified concerns is presented in Exhibit 6.3.[13] Additional information relating to effects on wastewater treatments systems is provided in Section 9.1.

The effluent characteristics for individual plants can vary significantly, but often include the following:[14]

- Marked tendency to foaming;
- Content of emulsified materials (e.g. fats and oils); and
- Sudden changes in nature and composition, due to batch dischargers of effluent from individual phases of the manufacturing process.

Potential contributing sources of the regulated loading parameters are primarily product losses, as summarized in Exhibit 6.4. Characteristics of individual loading parameters are described in the following sections.

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13 From presentation by R.Pickett, Metropolitan Toronto Works, to Soap and Detergents Association of Canada (SDAC) in spring of 1997.

14 For example refer to Fresenius, W. et al. (ed). 1989. Waste Water Technology: Origin, Collection, Treatment and Analysis of Waste Water. Springer-Verlag. pp91-97.

EXHIBIT 6.2: Processing Plant Effluent Discharge Alternatives

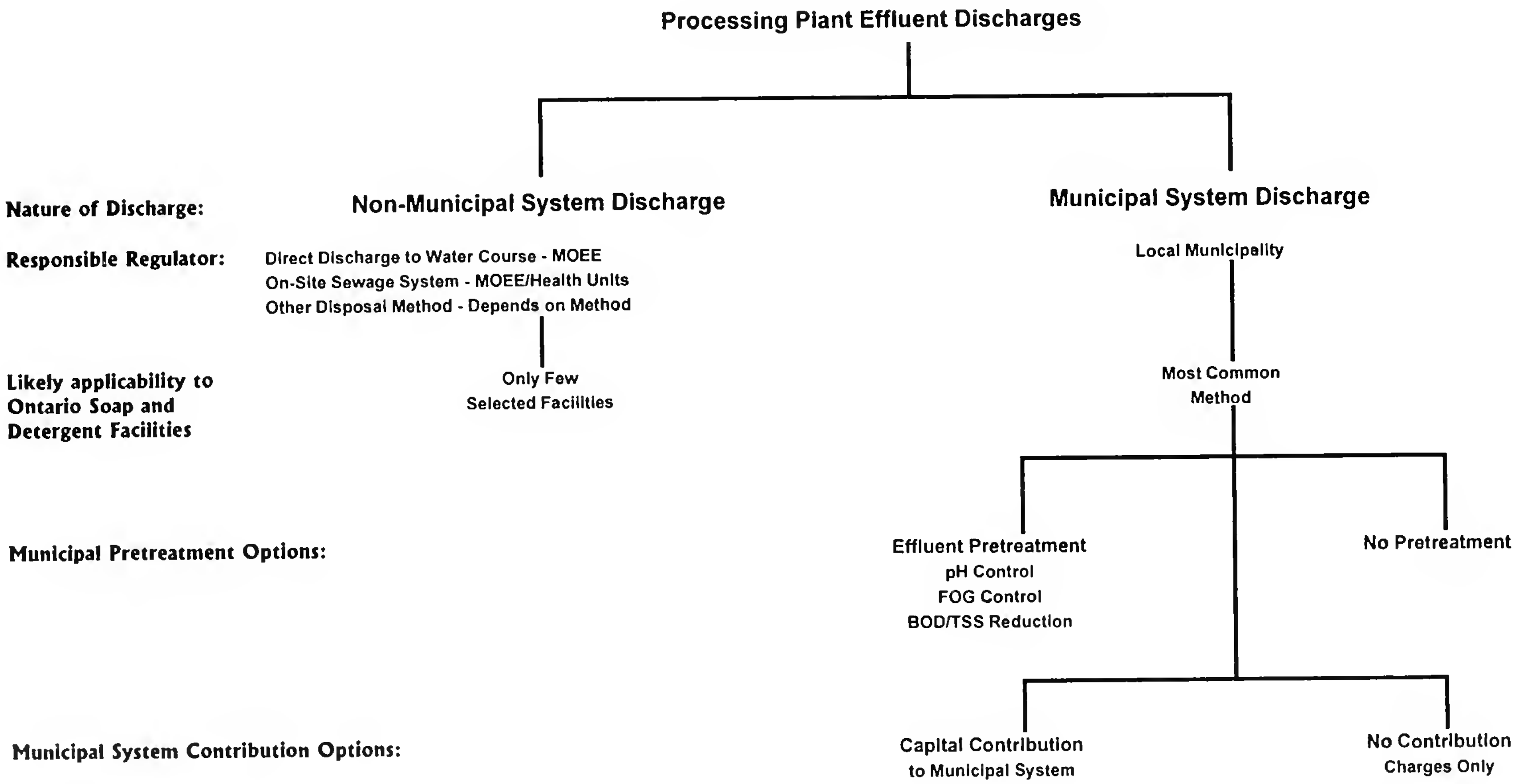

EXHIBIT 6.3: Identified Concerns Regarding Effects of Soap and Detergent Constituents on Municipal Wastewater Systems

COMPOUND GROUP	EFFECT CONCERNS
Builder Compounds (e.g. Sodium Tripolyphosphate (STPP) or Nitrilotriacetic Acid (NTA))	Interferes with precipitation. Complexes with metals and contributes to pass-through phenomena.
Foaming Agents and Foam	Obstructs/obscures visibility within sewers. May exit manholes from sewer system. Produces false readings on level sensing devices.
Phosphorus Compounds	Phosphorus discharges from municipal wastewater treatment systems is tightly regulated in Certificates of Approval.
Surfactants	May interfere with oxygen transfer in activated sludge processes, and in receiving water.

EXHIBIT 6.4: Generic Sources of Regulated Effluent Parameter Loadings

PARAMETER	POTENTIAL SOURCES
BOD	Organic component of surfactants and other additives.
TSS	Micelle globules and precipitates.
FOG	Organic (hydrophobic) component of surfactants and raw materials. May be of animal/vegetable or synthetic origin.
Phosphorus	Phosphates, primarily used for builders or additives.
Nitrogen	Nitrogenous components of surfactants or additives.
pH	Acid or caustic constituents.

EXHIBIT 6.5: Relative Degradation and Estimated BOD Contribution of Selected Materials

MATERIAL GROUP	EXAMPLE MATERIAL	APPROXIMATE BOD	BIODEGRADABILITY COMMENTS
Soap	Sodium Stearate	1.8 mg BOD/mg Material	Very high degradability
Glycerol (Glycerine)	Glycerol	0.5 mg BOD/mg Material	
Linear Alkylbenzene Sulphonate (LAS)	Sodium Dodecylbenzene Sulphonate	1.8 mg BOD/mg Material	Very high degradability
Fatty Alchohol Sulphate (AS)	Sodium Laural Sulphate	1.9 mg BOD/mg Material	
Cationic Quaternary Ammonium	Distearyldimethyl Ammonium Chloride	1.9 mg BOD/mg Material	Inhibitory (due to antimicrobial nature)
Alkyl Ethoxyate (AE)	Dodecanol-9-Ethoxylate	1.3 mg BOD/mg Material	Very high degradability
Alkyl Phenol Ethoxyate (APE)	Nonyl Phenyl-9-Ethoxylate	1.3 mg BOD/mg Material	Somewhat lower degradability
Amphoteric Carboxybetaine	Dodecyldimethylammonium Methane Carboxylate	1.6 mg BOD/mg Material	

6.1.3 Biological Oxygen Demand

An important discharge parameter for individual plants is effluent BOD. The generation of BOD is due to the degradation of organic product constituents. The relative degradability and approximate BOD contributions of the following selected example materials are summarized within Exhibit 6.5:

- Soap, for which sodium stearate is used as an example material;
- Glycerol (glycerine), which is a major byproduct of soap manufacturing;
- Linear Alkyl benzene Sulphonate (LAS), for which sodium dodecylbenzene sulphonate is used as an example material;
- Fatty Alcohol Sulphate (AS), for which sodium laurel sulphate is used as an example material;
- Cationic Quaternary Ammonium product, for which distearyldimethylamonnium chloride is used as an example material;
- Alkyl Ethoxylate (AE), for which dodecanol-9-ethoxylate is used as an example material;
- Alkyl Phenol Ethoxylate (APE), for which nonyl phenyl-9-ethoxylate is used as an example material; and
- Amphoteric Carboxybetaine, for which dodecyldimethylammoniummethane carboxylate is used as an example material.

Indications regarding biodegradability in Exhibit 6.5 are based on published information, especially recent collaborative work between the Dutch Ministry of the Environment (VROM) and the Dutch Soap and Detergents Association (NVZ).[15] The BOD contributions for each material are calculated, based on theoretical oxygen demand (ThOD) as determined from product chemical formulas.

As can be seen from the data in Exhibit 6.5, the calculated BOD contributions are all quite high. Although higher ratio values can be employed, a simple and conservative estimate of BOD from contributing soap and detergent products is as follows:

$$1 kg Surfactant \approx 1 kg BOD$$

Direct discharging plants, which provide on-site treatment in Private Sewage Treatment (PST) facilities, must ensure the final discharge BOD concentration does not exceed specific limits as prescribed by the MOE.

As described in Section 9.1, plants discharging to municipal sanitary sewer systems with effluent BOD concentrations that exceed By-Law limits may enter

[15] Association Internationale de la Savonnerie et de la Detergence (AIS) and the Comite Europeen des Agents de Surface et leurs Intermediaires Organiques (CESIO). 1995. Environmental Risk Assessment of Detergent Chemicals. Proceedings of the AISE/CESIO Limelette III Workshop. (November 28-29).

into a surcharge agreement, under which an additional surcharge is paid for the excess BOD. Municipal surcharge formulas and associated charges vary significantly among municipalities in Ontario, and no compiled data is available for the province as a whole. Within major industrialized municipalities, the effective surcharge for excess BOD typically ranges from approximately \$0.30 to \$0.60 per kg of BOD. The equivalent charge per kg of BOD can be even higher in smaller municipal centres.

While reduction of BOD can lead to surcharge reductions, it is important to note that such savings are small compared to the potential savings in recovered product. Using a cost range of \$0.30 to \$0.60 per kg of BOD, together with the simple BOD-to-product equivalent conversion presented earlier, the BOD value of lost product can be calculated as approximately \$0.30 to \$0.60 per kg. This is much lower than the typical value of product, in the range of approximately \$1.00 to \$5.00 per kg. Product savings can thus be approximated as roughly five to ten times the reduction of BOD charges.

6.1.4 Phosphorus and Nitrogen

Specific nutrient parameters of concern for effluent discharges are phosphorus and nitrogen. Environmental controls seek to reduce the discharge of phosphorus and nitrogen, which are both nutrients contributing to eutrophication in surface waters. Phosphorus and nitrogen can be present in constituent ingredients of soap and detergent products. Phosphorus and nitrogen effluent loadings are important for both direct dischargers and plants discharging to municipal systems.

In the case of direct dischargers, phosphorus limits are established by the MOE. In the case of municipal dischargers, municipal by-law concentration limits are established for phosphorus and nitrogen. These effluent concentration and/or loading limits are usually much lower than the limit for BOD. BOD is typically the parameter in largest excess, and therefore, of principal concern. However, as plants discharging to municipal systems reduce their product losses, and correspondingly their BOD discharges, potential excess phosphorus and/or nitrogen may become much more important.[16]

6.2 AIR-BORNE RESIDUALS

There are four major potential air-borne residuals important for soap, detergent and related product manufacturing. These are discussed in order of priority as follows:

- *Particulate Emissions from Drying Operations.* Particulate emissions result from powder product drying and handling operations. Such emissions are significant from a compliance perspective, as they fall

[16] Note that TSS and FOG can also be excess parameters, however, these, like BOD, result primarily from product losses. Reduction of product losses will also result in TSS and FOG reduction.

under the requirements of Regulation 346 of the Ontario *Environmental Protection Act*. Typically, bag-houses are employed to ensure that particulate emissions are maintained at satisfactory levels.

- *SOx, NOx and VOC Emissions from Surfactant Production.* Emissions may result from surfactant manufacturing operations, especially where gaseous reactants are employed, for example in sulfonation or in ethoxylation reactions. Such emissions are significant from a compliance perspective, as they fall under the requirements of Regulation 346 of the Ontario *Environmental Protection Act*, and are included in the Certificate of Approval from the MOE. Typically, caustic solution or other scrubbers are employed to ensure that emissions are maintained at satisfactory levels.
- *Combustion Emissions.* Boilers and heaters used to produce process heat contribute emissions from the combustion of fuels, in most cases natural gas. Such emissions will include CO_2, as well as NO_x, and small quantities of SO_2, CO and other constituents depending on the fuel and combustion conditions. Combustion emissions can be directly reduced by improvements in plant energy efficiency. A series of emission factors applicable to combustion operations are included in Exhibit 6.6.
- *Cooling Towers Emissions.* Cooling towers are employed for recirculated cooling systems, and may generate water vapour plumes.

6.3 SOLID WASTE RESIDUALS

A number of solid waste residuals result from processing operations, including packaging materials and sludges.

6.3.1 Packaging Residuals

Packaging residuals are important both in terms of the products manufactured by the industry, and in the manufacturing process itself.

The most significant solid waste residual of soap, detergents and related products manufacturing results downstream from product packaging. Given the nature of consumption of products, the majority of packages involve relatively small individual volumes. This leads to a large number of relatively small packages that are widely dispersed. Once the product is consumed, the packaging becomes a post-consumer solid waste.

EXHIBIT 6.6: Natural Gas Combustion System Emissions Factors

CONSTITUENT	CONDITIONS	KG OF EMISSIONS PER MILLION CUBIC METERS OF NATURAL GAS		
		Large Boilers (> 100 million BTU/h)	Small Boilers (10-100 million BTU/h)	Commercial Boilers (0.3-10 million BTU/h)
Carbon Dioxide		ND	1.9 E + 06	1.9 E + 06
Total Organic Carbon		28	92	128
Sulfur Dioxide		9.6	9.6	9.6
Nitrogen Oxides				
	Uncontrolled	8800	2240	1600
	Low NOx Burner	1300	1300	270
	Flue Gas Recirc	850	480	580

Note ND = No Data Available.
Emission Factors as cited in U.S. EPA AP-42 summary of emission factor data

The common consumer packaging formats used by the soap, detergents and related products industry include:

- High density polyethylene (HDPE) bottles, used for liquid products;
- Boxboard boxes, used for powdered products;
- Paper and boxboard, used for solid cake products; and
- Corrugated cardboard boxes, used for secondary packaging of smaller packages.

Additional formats including plastic pouches and other wrappings may be used but are less prominent.

Within manufacturing plants, solid waste residuals are also generated, resulting primarily from in-bound ingredient or product container packaging. These residuals are important both in terms of disposal costs and legislated waste reduction requirements. Important categories of solid waste materials generated within plants can include:

- Barrels;
- Plastic wrapping;
- Cardboard boxes; and
- Waste wood from broken or unusable pallets.

Environmental imperatives seek to reduce packaging, while consumer requirements and product safety and security aspects must be maintained. While it is incumbent upon the industry to manage its packaging through reduction, reuse and recycling, the function of packaging cannot be compromised.

A number of initiatives have been undertaken, or can be undertaken to reduce packaging wastes. These include the following:

- Suppliers of packaging, in concert with the industry, have been: (1) working to reduce the amount of raw material used in their packaging; (2) supporting recycling programs; and (3) developing end-use markets for their packaging while ensuring that the needs of the consumer are met.
- Plastic packaging displays the SPI "Plastics Recycling Coding System" which provides a universal identification system designed to assist consumers with sorting various plastic resin types.
- Minimum (post-use) recycled fibre specifications are established in corrugated and paperboard packaging containers.
- Heavy metals in packaging inks and adhesives are eliminated.
- Promotional material coatings on packaging (labelling) is converted to water-soluble products.
- Source reduction, using streamlined pouches instead of bulky rigid containers.
- Implementation of reusable pallet programs.
- Use of returnable totes for larger volume products.
- Initiation of packaging audits.

EXHIBIT 6.7: Compounds Cited in U.S. Toxic Release Inventory (TRI)
(Combined Citations for SIC's 2841, 2842 and 2843)

COMPOUND NAME	NUMBER OF TIMES COMPOUND IDENTIFIED				
	1994	1993	1992	1991	1990
Glycol Ethers	362	395	395	401	394
Phosphoric Acid	292	293	295	301	290
Sulphuric Acid	178	224	225	142	245
Hydrochloric Acid	173	173	169	175	175
Methanol	157	152	144	139	134
Ammonia	111	113	107	121	129
Diethanolamine	100	86	92	98	100
Ethylene	100	110	96	99	96
Ethlyene Glycol	90	97	89	87	92
Xylene (Mixed Isomers)	86	76	72	80	82
Nitric Acid	72	74	70	69	65
Toluene	64	66	68	79	79
Formaldehyde	55	52	53	54	54
Chlorine	54	58	65	59	61
Dichloromethane	51	59	65	78	86
Zinc Compounds	47	51	59	78	86
1,1,1-Trichloroethane	46	68	101	114	139
Tetrachloroethylene	41	34	34	43	51
Ethylene Oxide	32	30	28	35	30
Propylene	30	31	32	33	33
Maleic Anhydride	29	27	28	25	32
Listings for Identified Compounds	2170	2269	2287	2310	2453
Total Listings for All Compounds Used	2939	3073	3078	3100	3240
Percentage of Listings	74%	74%	74%	75%	76%

6.3.2 Waste Solid Product or Sludge Residuals

In addition to packaging materials, additional solid waste residuals may also be generated, although this is highly dependant on the nature of the process involved.

For powdered-product manufacturing or formulation operations, waste solid product may be generated, for example from spillages or losses from conveyance systems.

Sludge residuals may be generated in a plant. Such residuals are highly variable, and may include such things as spent filtration media or collected solids from effluent pretreatment (e.g. FOG separation).

6.4 CHEMICALS OF CONCERN

Documentation on the use and release of specific chemicals of concern was begun in 1993 in Canada with the National Pollutant Release Inventory (NPRI) by Environment Canada. As was described in Section 3.5, the NPRI approach was based on the Toxic Release Inventory (TRI) implemented in the US in 1986 by the Environmental Protection Agency (EPA). The TRI and NPRI databases were reviewed to determine the frequency of citation.

Substantial historical data is available from the TRI. Although this data is not for Canadian manufacturers, it provides an indication of the types of chemicals of concern used, and their relative frequency. Information compiled from the TRI is summarized in Exhibit 6.7. The most frequently identified chemicals are summarized for the five year period from 1990 though 1994 for the three US SIC categories:

- *US SIC 2841* Soap and other Detergents;
- *US SIC 2842* Specialty Cleaners; and
- *US SIC 2843* Surface Active Agents.

The chemicals indicated in Exhibit 6.7 represent approximately 75% of all chemical listings for the three SIC groupings in the TRI database. Note that data was reviewed only in terms of frequency of citation, and the information presented does not indicate the relative quantities of materials that may have been involved. The five most frequently cited chemicals in the TRI for the target SIC groups were, in order:

- Glycol Ethers;
- Phosphoric Acid;
- Sulphuric Acid;
- Hydrochloric Acid; and
- Methanol.

More limited data is available from the 1993 NPRI inventory.[17] A review identified a relatively small number of citations for the soap and detergent sector, including approximately 15 establishments and approximately 30 different chemicals. The most frequently cited chemicals for 1993 were, in order:

- Isopropyl Alcohol;
- Phosphoric Acid;
- Sulphuric Acid;
- Hydrochloric Acid; and
- Nitric Acid.

6.4.1 Nonylphenol and its Ethoxylates (NPEs)

Nonylphenol and its Ethoxylates (NPEs) are among 25 substances on the federal Ministers of Environment and Health second Priority Substances List. NPEs are discharged into the environment primarily from textile and pulp and paper production facilities. They are also used in some detergents, coal processing, latex paints, grease and lubricating oils, and pesticides.

Acute adverse effects have been reported in laboratory studies of invertebrates, fish, mammals and algae. There are also concerns that these substances may interfere with endocrine function. An assessment has been started to determine exposure levels and the risk they may pose to the environment and human health in Canada. The assessment will take into account the inherent toxicity of the substance, the likelihood of releases into the environment and the harm it may cause to human health or ecosystems. Environment Canada scientists are currently leading a review of the occurrence, persistence and effects of NP and its ethoxylates in the environment.

To ensure that current and relevant information is used to assess the likelihood of release into the environment, all companies, including soap and detergent companies, operating in Canada who are involved with 1000 kg or more of NPEs were required to complete and return a survey on the production, imports, exports, use, release and monitoring of NPEs by July 1, 1997. The survey was distributed under authority of the Canadian Environmental Protection Act.

A draft report is expected for comment in early (March) 1998. The final assessment report is expected in 1999. If NP and its ethoxylates are found to be toxic as defined under the Canadian Environmental Protection Act, stakeholders and other interested parties will be consulted to develop a plan to reduce their use and release into the environment.

Updates of the status of the NPE and other ecological risk assessments will be posted on the Internet http://www.doe.ca/cceb1/eng/psap.htm.

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17 NPRI data is only readily available for 1993, and is not searchable by SIC grouping.

7.0 GENERIC PROCESS IMPROVEMENT OPPORTUNITIES

The most important opportunities for soap, detergent and related products manufacturing result from the reduction of product losses, irrespective of the process involved. The value of materials lost through waste, effluent discharge or other losses is typically much higher than the cost of disposal, treatment or surcharges that may be incurred. In some cases the product value can be as much as ten times higher or more. Reduction of product losses thus yields a substantial double benefit, simultaneously increasing saleable product revenues and reducing treatment or disposal charges.

Additional significant opportunities may also be present in the improvement of utility and service systems at manufacturing plants, including: steam; heating; hot water; cooling; and compressed air. Such opportunities result in reduced energy costs, and often involve low cost or operational improvements, that can be rapidly implemented with little or no capital requirements.

For each of the five basic processes, a concise generic checklist of process improvement opportunities is provided in the form of a table as follows:

- Soap Production - Exhibit 7.1.
- Surfactant Production - Exhibit 7.2.
- Cake Product Formulation - Exhibit 7.3.
- Liquid Product Formulation - Exhibit 7.4.
- Granulated Powdered Product Formulation - Exhibit 7.5.

These checklists will assist in the identification of process related improvement opportunities incorporating energy/water efficiency and pollution prevention. Each checklist covers the same sequence of activities as the generic process diagrams, and provides:

- Identification of thermal, electrical, environmental and water use implications;
- Low cost/no cost measures that can be implemented; and
- Applicable retrofit technology options, cross referenced to Exhibit 7.6.

In general, for soap, detergent and related compounds manufacturing, the largest overall potential savings are associated with product loss reduction, while the largest technology-related savings opportunities involve utilities and services.

7.1 LOW-COST/NO-COST OPPORTUNITIES

Low-cost/no-cost opportunities, involving minor capital items, are identified as such in the process tables. The probable cost of implementing opportunities in the category is typically no more than approximately $5,000. The low-cost/no-cost measures also typically have pay backs in the range of no more than 1 to 1.5 years.

EXHIBIT 7.1: Checklist of Improvement Opportunities for Soap Production

PROCESS AREA	CONCERNS: Thermal	CONCERNS: Power	CONCERNS: Environment	CONCERNS: Water	OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *
Storage	Heating required for product movement	Viscous product pumping			Minimize heating of storage. Only heat when product about to be used		
Kettle Cooking	Heating for product reaction	Agitation during reaction - viscous nature	Vapour discharge			Process waste heat recovery	2
Soap Separation			High BOD from glycerol content if not recovered			Glycerol recovery (membrane) or other more conventional system.	1
Kettle Cleaning	Heated water may be used to ensure residual soluabilization		Potentially high BOD from residual product	Rinse water	Ensure product removed to minimum. Use air blow, wiper systems or simple foam balls or "pigs" to clean transfer lines.	Membrane processing for final residual recovery	1
					Reusing cleaning water, especially as first rinse, and only using fresh water for final flushes.		
					Employ nozzles, burst rinsing for cleaning with minimum water. Ensure that as much product removed as possible.		
Hydrolysis	High temperature reaction, require signficant energy	Pumping	Fugative emissions of VOCs and odours			Process heat recovery Link to membrane processing to allow water recycle for feed water.	2
Glycerol Evaporation	Steam input to concentrate glycerol residuals		Potentially high BOD from entrainment losses, VOCs	Cooling water	Ensure entrainment systems operating properly.	Membrane recovery on residual evaporator condensates to recover product and water, and reduce BOD.	1
Fatty Acid Neutralization		Agitation to ensure complete reaction					

* NOTE: SEE EXHIBIT 7.6 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

EXHIBIT 7.2: Checklist of Improvement Opportunities for Surfactant Production

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *
	Thermal	Power	Environment	Water			
Storage	Heating required for product movement	Viscous product pumping			Minimize heating of storage. Only heat when product about to be used		
Kettle Cooking	Heating for product reaction	Agitation during reaction - viscous nature	Vapour discharge			Process waste heat recovery	2
Kettle Cleaning	Heated water may be used to ensure residual soluabilization		Potentially high BOD from residual product	Rinse water	Ensure product removed to minimum. Use air blow or simple foam balls or "pigs" to clean transfer lines.	Mechanical wiper systems on reactor vessels.	4
					Reusing cleaning water, especially as first rinse, and only using fresh water for final flushes.		
					Employ nozzles, burst rinsing for cleaning with minimum water. Ensure that as much product removed as possible.	Membrane processing for final residual recovery.	1
					Batch scheduling of products to allow use of remaining residuals from one batch into the next.	Interface detection sensor.	5
Surfactant Reaction	High temperature reaction, require signficant energy	Pumping, Blowing of gaseous reactants	Potential emissions of SOx, NOx, VOCs, odours and particulates. Environmental load may be transfered to liquid effluent	Scubber system			
Neutralization		Agitation to ensure complete reaction					

* NOTE: SEE EXHIBIT 7 6 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

EXHIBIT 7.3: Checklist of Improvement Opportunities for Solid Cake Product Formulation

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *
	Thermal	Power	Environment	Water			
Storage	Heating required for product movement				Minimize heating of storage. Only heat when product about to be used		
Drying	Energy for drying of product to produce flaked product	Pumping	Vapour discharge psssible, with associated VOC				
Milling System		Milling Drives					
Ingredient Mixing		Agitation					
Mold Press	May be heated, and cooled to assist in mold release	Electric Drives					
Cake Trimming		Electric Drives			Reworking of trimmed product (standard practice)		
Packaging		Electric Drives	Packaging Materials				
Palleting		Electric Drives	Packaging Materials				

* NOTE: SEE EXHIBIT 7 6 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

EXHIBIT 7.4: Checklist of Improvement Opportunities for Liquid Product Formulation

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *
	Thermal	Power	Environment	Water			
Storage		Pumping					
Mixing and Blending	Some product heating may be necessary	Agitation	VOC emissions				
Kettle Cleaning	Heated water may be used to ensure residual soluabilization		Potentially high BOD from residual product	Rinse water	Ensure product removed to minimum. Use air blow or simple foam balls or "pigs" to clean transfer lines.	Mechanical wiper systems on reactor vessels.	4
					Employ nozzles, burst rinsing for cleaning with minimum water. Ensure that as much product removed as possible.	Membrane processing for final residual recovery.	1
					Batch scheduling of products to allow use of remaining residuals from one batch into the next.	Interface detection sensor.	5
					Reusing cleaning water, especially as first rinse, and only using fresh water for final flushes.		
Filling and Packaging		Electric Drives	Packaging Materials		Ensure proper maintenance to reduce product losses at filling stage.		
Palleting		Electric Drives	Packaging Materials				

* NOTE: SEE EXHIBIT 7.6 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

EXHIBIT 7.5: Checklist of Improvement Opportunities for Granulated Powdered Product Formulation

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *
	Thermal	Power	Environment	Water			
Storage			Dust control for powdered products				
Slurry Mix	Heating may be needed to enhance produce mixing	Agitation	Vapour discharge psssible, with associated VOC	Small product water addition			
Spray Tower Air Heating	High volume air flow heating, liquid product heating	Blower Drives				Agglomerator technology for reduced energy requirements. Note that agglomeration technology is well established as a separate process.	
Spray Tower Wet Scrubber			NOx, SOx, particulate, and VOC emissions. BOD in scrubber drainage to liquid effluent	Water flow for scrubbing			
Agglomeration Unit		Electric Drives				Much less energy intensive than spray tower technology	
Agglomeration Unit Dryer	Air flow at lower temperature for residual drying of ingredients	Electric Drives	Dust				
Agglomeration Unit Baghouse			VOC, particulate emissions				
Dry Mixing System		Electric Drives				Least resource intensive powdered product process, but depends on nature of process.	
Filling and Packaging		Electric Drives	Packaging materials			Conveying System Improvements to minimize product transport and losses.	3
Palletizing		Electric Drives	Packaging materials				

* NOTE: SEE EXHIBIT 7.6 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

EXHIBIT 7.6: Checklist of Retrofit Options for Soap and Detergent Manufacturing

REF NO.	RETROFIT	EQUIPMENT	COSTS	SAVINGS	PAYBACK	COMMENTS/ BENEFITS
1	Membrane recovery system for dilute glycerol by product and soap residual recovery	Membrane system (nanofiltration to ultrafiltration)	200-500k	50-300k	2-5 yrs	Reduces effluent load and provides upgraded water, usable for recycle. Enhanced opportunity if product can be recovered for reuse.
2	Process waste heat recovery for primary manufacturing.	Heat exchangers	20-100k	10-70k	1-3 yrs	Recovery of waste heat may be more limited in batch operations. Sequencing of batches may be possible to increase heat recovery.
3	Powder product conveying	System improvements	10-100k	20-60k	1-2 yrs	System improvements to reduce leakage points for pneumatic, and minmize holdup points on conveyors
4	Mechanical wiper systems	Wiper system for product residual	20-60k	10-40k	1-2 yrs	Reduction of product losses.
5	Interface detection sensor	Sensor	30-60k	10-40k	1-3 yrs	Minimization of losses during cleanouts.

7.2 RETROFIT OPPORTUNITIES

In Exhibit 7.6, the retrofit options applicable to direct process improvements are summarized and categorized into technology groups. For each, a range of probable capital costs, probable savings and resulting pay-back are presented. Each of these technology groups is generic. Information presented should be only be used as a guide for assessing applicability and viability at specific plants.

7.3 UTILITY-RELATED OPPORTUNITIES

A checklist of generic utility and services improvements is presented in Exhibit 7.7. This checklist is outlined in the almost the same format as the process technology checklists.

7.4 OTHER IMPROVEMENT MEASURES

In addition to the low-cost/no-cost and retrofit technology opportunities, it is also important to consider opportunities associated with management practices, training and awareness:

- *Management commitment to energy/water-use reduction and environmental improvement.* Any effective energy/water management and pollution prevention program must have the endorsement of top level management. A clear commitment by management is essential to achieving financial, image and societal benefits through pollution prevention.
- *In-plant training and awareness of energy/water/environment.* In processing plants, operators often have discretion over the quantities of water, input raw materials, and energy utilized in relation to tasks performed. Plant personnel should be trained in operational techniques that lead to cost reduction and environmental improvement.

EXHIBIT 7.7: Check List of Improvement Opportunities for Utilities and Services

UTILITY SERVICE	ENERGY IMPLICATIONS: Thermal	ENERGY IMPLICATIONS: Electrical	ENERGY IMPLICATIONS: Water	OPPORTUNITY: LOW COST/NO COST	OPPORTUNITY: RETROFIT	COSTS (000's)	SAVINGS (000's)	PAYBACK (yrs)	COMMENTS
City Water			Veriabla, for process, weshup end utility cooling	Water meters in different process areas to monitor consumption on an on-going basis.		low cost / site specific			Trend data to identify zones/ equipment/ crews with either inconsistent or inefficient performance.
				Enhanced insulation of cold water piping lines.		low cost / site specific			Reduce cooling load on chillers and heating load on boilers
				Pump impeller optimization (impeller changeout).		low cost / site specific			Ensure duty point is within optimum zone on pump curve.
				Pump maintenance program.		low cost / site specific			Regular inspection and maintenance to trend performance for early indication of failure.
				Recycle once-through cooling water to process or other uses.		low cost / site specific			Once through cooling water is inefficiant and costly in terms of walar and sewega. Rautiliza in a cascade systam.
					Closed loop cooling water systems (cooling towers).	25-100	15-50	1-3	Once through cooling water is inefficient and costly in terms of water and sewage.
					Veriable speed pump drives to optimize flows.	5-20	3-12	1-3	Minimize costly bypass provisions which are wasteful for pumping systems.
Hot Water	Variablo, for washup and process			Enhanced insulation of HW tanks end lines, and hot process vessels.		low cost / site specific			Matching thermal services to demand requirements.
				Ensure appropriate water heating set points.		low cost / site specific			Minimize cold water tempering to reduce overheated water temperature to process conditions.
				Pump impeller optimization (impeller changeout).		low cost / site specific			Ensure duty point is within optimum zone on pump curve.
				Pump maintenance program.		low cost / site specific			Regular inspection and maintenance to trend performance for early indication of failure.
					Infrared heating system for large open areas.	10-20	3-12	1-3	Heats occupants rather than space.
					Segragate HW system according to temparatura requiremants to reduce unnecessary tempering	10-30	5-15	2-4	Consider multipla boilers each feeding loads at a similar temperature. All loads should not be dictatad by tha highast temperature.
					High efficiency hot water heater system.	5-50	3-20	1-3	Many new units in 95% efficiency range with condensing heat recovery.
Steam	Natural ges typical			Tune boiler combustion air to achieve optimum fuel/air mixture.		low cost / site specific			Optimum operation point yeilds reduced gas costs and emissions.
				Use interruptible gas service at lower cost, if appropriate		low cost / site specific			Only essential loads should be on non-interuptible contracts.
				Blow down heat recovery (heating washup water, boiler feed water etc.)		low cost / site specific			Utilize heat from blowdown to preheat incoming city watar and reduce city water tempering to discharge guidelinas
				Identify and correct steam and condensate leaks		low cost / site specific			Leak represents a point through which contamination is possible.
				Collect all possibla condensate and insulate staam and condensata ratum lines		low cost / site specific			Waste of energy and and treatment chemicals.
				Steam trap maintenance program.		low cost / site specific			Ensure optimum performance of traps to reduce downtime of steam system.
				Chemical treatment program to maintain opereting performance.		low cost / site specific			Reduce scaling and fouling factor losses at point of heat exchange. Scale build up increases pumping resistance.,

Steam (continued)				Maintain control setting to ensure no overheating.		low cost / site specific			Wasteful practice to overheat, better quality and consistency in the product.
				Monitor steam consumption to avoid surges.		low cost / site specific			Trend data to identify equipment with either inconsistent or inefficient performance.
					Flash steam recovery from condensate.	5-10	3-5	1-3	Low pressure steam may be recovered from condensate for use elsewhere.
					Replace steam boiler with hot water heaters if appropriate	2-150	10-40	2-5	Hot water boilers operation and maintenance costs tend to be lower.
					Infrared heating system for large open areas.	10-20	3-12	1-3	Heats occupants rather than space.
					Steam powered condensate return pumps to replace electrical pumps.	2-10	1-5	1-2	Utilize steam power to return condensate rather than electricity.
					Flue gas heat recover, direct contact condensing heat recovery	10-40	5-12	2-5	Further preheating of feedwater with stack gases downstream of economizer.
					Heat exchange rather then direct injection	10-50	5-15	2-3	Steam injection consumes water which necessitates city water make up and heating.
Compressed Air		Electrical drives		Analyze for air leaks and repair		low cost / site specific			Ultrasonic detection equipment available
				Enclose compressor to eliminate heat rejection into building space were not desired.		low cost / site specific			Ensure radiant heat from unit is not admitted to a cool space where it must be recooled.
					Engine driven compressor.	150-400	75-100	1-3	Less expensive energy input, better part load efficiency than electrical motors, heat recovery from engine jacket and exhaust.
					Buffer tank to regulate compressor duty cycle.	5-15	3-5	1-3	Newer systems tend to incorporate. Should be considered for older systems.
					Compressor heat recovery	5-15	3-5	1-3	Recover heat from compressor for preheating rather than paying to cool it.
Electrical (Direct Uses)		Electrical drives		Reduce unnecessary lighting, replace with higher efficiency lights.		low cost / site specific			Ensure lights (heat sources) not left on unnecessarily in cold spaces. Utilize high efficiency, long life replacements.
					Variable speed drives.	5-20	3-12	1-3	Minimize costly bypass provisions which are wasteful for pumping systems.
					Power factor correction to reduce surcharge	10-25	4-12	2-3	Reduce penalty imposed by electrical utility for inefficient operation by sizing a capacitor correction system.
					High efficiency motor drives	100-200	30-100	2-3	Substantial increases in efficiency. High efficiency motors replace standard motors when replacement is necessary.
Cogeneration					Combined thermal energy and power production	600-3000	150-800	3-7	One fuel source simultaneously providing 2 or more forms of energy.

EXHIBIT 8.1: New Technologies for Soap and Detergent Processing

REF NO.	NAME OF TECHNOLOGY	DESCRIPTION OF TECHNOLOGY	APPLICATION	
			PROCESS	ACTIVITY
1	Expert Computer Control Systems	Expert control systems incorporate enhanced computer control to coordinate and optimize process operations. Expert control systems are now becoming commercialized, but are not yet extensively used. The costs of these systems are still relatively high, but are decreasing.	All	Control of Process Operations
2	On-Line Monitoring Sensor Technologies	Enhanced sensors allow for on-line, real time monitoring of processing activities and process conditions. The capabilities allowed by on-line monitoring include reduce energy and water use, and enhanced product yield, with reduced losses.	Primary Ingredient Processes	Enhanced Monitoring of Process Operations
3	Superheated Steam Drying (SSD)	Superheated steam drying (SSD) is a highly efficient new drying technology that allows the reuse of recovered evaporation as useful steam. Such systems are already commercial in Europe for other industries. The technology is not likely to be justifiable for a strict retrofit operation, however, could be considered for a situation where a new or replacement powder drying system is required.	Dried Powdered Product	Drying
4	Pulsed Drying Systems	Pulsed drying technology has achieved some commercialization. Such systems may incorporate pulsed combustion spray drying or pulsed fluidized beds, however the principal is the same. By providing pulsed or oscillating heating, such as rapidly alternating on-off pulsed combustion, the total energy input to the drying system is reduced significantly. Such technologies may be justified for some retrofits, and may be considered for new installations.	Dried Powdered Product	Drying
5	Advanced High-Rate Anaerobic Wastewater Treatment Systems	The high potential strength of effluents is a concern when biological treatment or pretreatment may be required. The development of compact, high-rate anaerobic treatment systems, which produce low amounts of sludge are advantageous and can help to resolve this concern.	All	Effluents
6	Aerobic/Anaerobic Membrane Bioreactor	A radical potential improvement in wastewater treatment can be achieved through the use of compact, high-rate membrane bioreactor systems, operated either aerobically or anaerobically. Such systems have already become commercialized, but not applied to this industry.	All	Effluents

8.0 NEW TECHNOLOGIES

Within the soap, detergents and related products sector, the primary focus of research and development has been on new products and new product formulations, rather than on new process technologies. Process developments have generally followed product developments, based on requirements to achieve specific product characteristics.

New technologies applicable to energy/water efficiency and pollution prevention in soap and detergent processing plants are summarized in Exhibit 8.1. This list is not intended to be comprehensive, and is only a starting point for site-specific evaluations. Other new technologies are also under development, which relate primarily to productivity improvement or product development. However, any such technologies, with little or no impact on pollution prevention or resource savings, have not been included here.[18]

The new technologies are briefly described as follows:

- *Expert control systems.* These systems incorporate enhanced computer control to coordinate and optimize process operations, minimizing energy use and product losses, which result in environmental loads.
- *On-line monitoring.* The development of on-line monitoring systems has been progressing rapidly in concert with computer controls. Such probes allow for more accurate, direct and rapid acquisition of process data, helping to minimize processing requirements, and consequently, energy and water use as well as product losses.
- *Superheated steam drying.* This highly efficient drying method, allows for the reuse of recovered evaporation as useful steam. The technology is commercially applied in Europe in other industries, and may be adaptable to specific processes incorporating drying.
- *Pulsed drying systems.* A number of such technologies have been developed, which can reduce energy inputs to drying operations. Some technologies have been commercialized, although not yet applied. Such systems also may be adaptable to specific processes incorporating drying.
- *Advanced high-rate anaerobic wastewater treatment systems.* High rate systems to more effectively deal with potentially high strength effluents.
- *Aerobic/anaerobic membrane bioreactor.* Such compact systems provide substantially improved performance, especially for dealing with high strength effluent.
- *Sugar-based surfactants and antimicrobial compounds.* A five year project is underway at the Columbia University Center for Surfactants to create more effective detergents using surface-acting polyglucosides as cleaning agents.

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[18] A array of new processing approaches is for example described in: Hill, M. and R. Ahart. 1996. Advances in Detergent Processing. New Horizons: AOCS/CSMA Detergent Industry Conference. AOCS Press. pp37-41. In most cases, however, the processing advances have little direct impact on resource conservation.

EXHIBIT 9.1: Summary of Relevant Regulations

CATEGORY		LEGISLATION, REGULATION, GUIDELINE	FED OR PROV	ADMINISTERING AGENCY	PURPOSE
Product/Substance Controls		Canadian Environmental Protection Act	Federal	EC	Control of substances through various "control" lists
		Food and Drug Act	Federal	HC	Designates specific materials as "drugs" with associated procedural and registration requirements
		Pest Control Products Act	Federal	HC	Designates specific materials as "pest control agents" with associated procedural and registration requirements.
Notification *		Environmental Bill of Rights	Provincial	MOE	Public notification of acts, instruments and actions of designated Ministries, including MOE.
All Potential Discharges		Certificate of Approval under Environmental Protection Act	Provincial	MOE	Control of plant discharges
Effluent	Direct Discharge	Fisheries Act	Federal	EC	Control of direct discharges to receiving bodies of water
		Ontario Water Resources Act	Provincial	MOE	Control of direct discharges to receiving bodies of water
		Environmental Protection Act	Provincial	MOE	Control of direct discharges to receiving bodies of water
		Regulation 63/95	Provincial	MOE	MISA regulation for control of specific discharge parameters for specified organic chemical plants
		Environmental Protection Act Regulation 358	Provincial	MOE	Control of sewage systems
	Sewer Discharge	Municipal Act	Provincial	Municipalities	Authority for By-Laws to control municipal sanitary sewer discharges
		Environmental Protection Act Regulation 347	Provincial	Municipalities	Through Municipal By-Laws, defines materials that are not permitted to be discharged
		Ontario Water Resources Act	Provincial	Provincial	Control of certain discharges to storm sewer may also be subject to Section 53 of the Act.
Air	Particulates	Regulation 346	Provincial	MOE	Control of emissions. Relevant to dryers.
	Odours	Environmental Protection Act	Provincial	MOE	Control of odours
Solid Waste	General	Regulation 102/94	Provincial	MOE	Waste auditing and reduction
		Regulation 103/95	Provincial	MOE	Source segregation of wastes
	Packaging	National Packaging Protocol	Interprovincial	CCME	Packaging reductions
		Regulation 104/94	Provincial	MOE	Package auditing and reduction
Wastes	General	Environmental Protection Act Regulation 347	Provincial	MOE	Control of waste management, hazardous wastes and industrial wastes

* Companies are not directly subject to the EBR, however, applications to the Ministry may be posted on the registry for public review. The registry can also be a source of information about environmentally significant measures related to the soap and detergent sector being undertaken by the Ontario government.

9.0 REGULATORY OVERVIEW

Soap, detergents and related products processing in Canada is subject to regulations. The two most important areas of regulation involve:

- Control of environmental releases; and
- Product quality and safety, including product registration requirements.

Each of the major relevant regulatory areas is discussed in the following sections, with an overview of regulations presented in Exhibit 9.1.

9.1 WATER-BORNE RESIDUAL REGULATIONS

The nature of the regulations applied to effluents and associated water-borne residuals depends on the discharge from a specific plant:

- Discharges to municipal sanitary and storm sewer systems or sewage works are controlled by the responsible Municipality, although discharges to a municipal storm sewer may also be subject to control by the MOE under the *Ontario Water Resources Act.*
- Direct discharges to a surface water receiving stream or body after on-site treatment in a Private Sewage Treatment (PST) system are regulated directly by the MOE, primarily under the *Ontario Environmental Protection Act, and the Ontario Water Resources Act.*

A small number of facilities in Ontario discharge directly into a water body. In these cases, an assessment of the receiving body is undertaken, and appropriate discharge limits are established, based on conditions of the receiving stream. Direct discharge limit values are public, however, this data is maintained by the various District Offices of the MOE, and no aggregate data is currently available for the province. Direct dischargers are not permitted to exceed their designated limits. Any non-conformities must be reported to the MOE.

Most soap and detergent facilities in Ontario discharge effluent to municipal sanitary sewer systems for ultimate treatment at a local municipal wastewater facility. These firms must comply with local municipal sewer by-laws, which are enacted under the authority of the *Ontario Municipal Act.* The by-laws set limits for effluent parameters. Although some differences exist between individual by-laws, most tend to follow the structure and limits recommended under the MOE's Model Sewer Use By-Law.[19] Discharges of process effluents to storm sewers are typically not permitted. Discharges to sanitary/combined sewers are permitted, however, with limits. The limit values, as outlined in the Model Sewer Use By-Law, for the common major effluent parameters are summarized as follows:

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[19] Ontario Ministry of the Environment. 1988. Model Sewer Use By-Law. ISBN 0-7729-4419-9.

PARAMETER	LIMIT VALUE	REFERENCE[20]
Biological Oxygen Demand (BOD)	300 mg/L	2 (1) 2 (i)
Total Suspended Solids (TSS)	350 mg/L	2 (1) 2 (j)
Solvent Extractables of Mineral or Synthetic Origin	15 mg/L	2 (1) 2 (g)
Solvent Extractables of Animal or Vegetable Origin	150 mg/L	2 (1) 2 (h)
Total Phosphorus	10 mg/L	2 (1) 2 (k)
Total Kjeldahl Nitrogen (TKN)	100 mg/L	2 (1) 2 (l)
pH	5.5 to 9.5	2 (1) 2 (f)

The limit values applied to BOD and TSS reflect parameter concentrations approximately 50% higher than that normally found in domestic or residential sewage.[21]

In addition to the major common parameter limits outlined above, other limits are provided in the Model Sewer Use By-Law, and are also typically incorporated into specific municipal by-laws for sanitary/combined sewers. These limits include the following:

- Discharges of chlorides (expressed as Cl) and sulphates (expressed as (SO_4) are limited to 1,500 mg/L (under Subclause 2 (1) 2 (p)).
- Discharges of effluents containing persistent dyes or colouring materials, that would discolour the final effluent of a municipal wastewater treatment facility, are prohibited (under Subclause 2 (1) 2 (o)).
- Discharges of "pesticides", as defined under the Ontario *Pesticides Act,* are prohibited (under Subclause 2 (1) 2 (q)). This definition effectively refers to all control products registered under the Federal *Pest Control Products Act.*
- Discharges of "severely toxic materials", "acute hazardous waste chemicals", "hazardous waste chemicals" and "hazardous industrial wastes" are all prohibited (under Subclauses 2 (1) 2 (q) and 2 (1) 2 (s)). These categories are all specifically defined within Regulation 347 (Waste Management - General) under the Ontario *Environmental Protection Act,* including listed schedules of designated materials and chemicals.

The concentrations of certain effluent parameters for discharges to sanitary/combined sewers are often allowed to exceed the municipal by-law limits,

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20 Ontario Ministry of the Environment. 1988. Model Sewer Use By-Law. ISBN 0-7729-4419-9.

21 Ontario Ministry of the Environment. 1988. Model Sewer Use By-Law: Appendix/Guidance Manual. ISBN 0-7729-4419-9. p21.

under a negotiated surcharge agreement. The nature of surcharges varies between municipalities, in terms of eligible parameters, allowable parameter limits and associated charge formulas:

- Parameters allowable for surcharge vary somewhat between municipalities, but typically include BOD, TSS and total phosphorus. A surcharge agreement is not typically allowed for pH exceedance, nor for the discharge of prohibited materials.
- Allowable limits for discharge parameters under a surcharge agreement vary somewhat between municipalities. For example, surcharge agreement limits for BOD are typically around 3,000 mg/L, but may vary as high as 10,000 to 15,000 mg/L.
- Surcharge formulas and unit parameter charges vary significantly between municipalities within Ontario. Surcharge approaches applied by individual municipalities include: no surcharge; surcharge based solely on volume; surcharge based on single maximum parameter exceedance; and surcharge based on simultaneous multiple parameter exceedances. Within the actual calculation formula, exceedance differences or exceedance ratios may also be employed by different municipalities. Excess parameter charges also vary. For example, charges for excess BOD within Ontario currently vary between approximately $0.30 to $0.60 per kg. BOD is typically the largest parameter and is also typically the largest excess parameter surcharged. As a result, municipalities tend to focus on BOD monitoring.

Under municipal sewer use by-laws, discharge limits and restrictions are provided for storm sewer discharge. Such limits, however, are not discussed in detail here because process discharges to storm sewers are not typically permitted by municipalities.

9.2 AIR-BORNE RESIDUAL REGULATIONS

Air-borne emission regulations can be important for soap, detergent and related product plants depending on the nature of the processes involved. As described in Section 6.2, these emissions can include: boiler and other combustion emissions; cooling towers; particulate and other emissions that may result from drying and handling operations; and process emissions, which may be either fugitive (i.e. unintended) in nature or process determined (i.e. from a stack).

In Ontario, administration of air-borne emission releases is dealt with directly by the Ministry of the Environment. Facilities are required to obtain a Certificate of Approval (Air) under the *Ontario Environmental Protection Act* and Regulation 346 (Air Pollution). This regulation outlines a methodology for determining Point of Impingement Concentrations and specifies maximum limit concentrations for certain materials. Additional requirements and limits may be specified by the Ministry under the terms of a Certificate of Approval. Concentration limits from Regulation 346, which apply to soap, detergents and related products manufacture are summarized as follows:

CONTAMINANT	MAXIMUM CONCENTRATION AT POINT OF IMPINGEMENT (HALF HOUR AVERAGE)
Suspended Particulate Matter (less than 44 mm size)	100 mg of total suspended matter per m^3 of air
Sulphur Dioxide	830 mg of sulphur dioxide per m^3 of air
Nitrogen Oxides	500 mg of nitrogen oxides per m^3 of air expressed as NO_2.

Another potential air impact is odour. This is also covered under the *Ontario Environmental Protection Act* but under more general provisions. There is a potential for concern if objectionable odours are present from processing or waste treatment activities.

9.3 SOLID WASTE REGULATIONS

Regulations 102, 103 and 104 came into effect in 1994 under the *Ontario Environmental Protection Act*. These regulations are more commonly referred to as the "3R's Regulations". They require industrial establishments to conduct source segregation of materials, to undertake waste and packaging audits, and to develop work plans for reductions. The intent of these regulations is to support a national commitment made in 1989 by the Canadian Council of Ministers of the Environment (CCME). CCME also adopted the National Packaging Protocol (NAPP) in 1990, which similarly calls for the quantity of packaging sent for disposal in the year 2000 to be no more than 50% of the amount sent for disposal in 1987.

Regulation 102 (Waste Audits and Waste Reduction Work plans) deals with the requirements for Industrial, Commercial and Institutional generators to conduct waste audits and prepare waste reduction work plans. This regulation puts the responsibility on Industrial, Commercial and Institutional operations to undertake waste reduction. The threshold for whether a specific facility is required to undertake audits and reduction work plans is determined by the number of full-time equivalent employees, currently being approximately 100 at a given site.

Regulation 103 (Industrial, Commercial and Institutional Source Segregation Programs) deals with the requirements for Industrial, Commercial, Institutional generators to implement source separation programs. There are 11 specific materials categories that must be segregated by industrial generators: (1) aluminum; (2) cardboard; (3) fine paper; (4) glass; (5) newspaper; (6) polyethylene (high density); (7) polyethylene (low density); (8) polystyrene (expanded); (9) polystyrene (rigid); (10) steel; and (11) wood (not treated, painted or laminated).

Regulation 104 (Packaging Audits and Packaging Reduction Work plans) deals with the requirements for specific sectors and operations to conduct packaging audits and prepare packaging reduction work plans. Chemicals manufacturing is one of the sectors subject to Regulation 104. This means that soap, detergents and related products manufacturing establishments with more than 100 employees are required to conduct audits and prepare packaging reduction work plans. Importers are also required to conduct packaging audits.

Regulation 347 (Waste Management General) governs waste management within Ontario, and provides definitions of:

- Recyclable materials;
- Specific types and categories of hazardous materials; and
- Liquid industrial waste.

Other liquid and solid wastes, such as sludges, are also regulated here.

9.4 HAZARDOUS WASTE REGULATIONS

Soap, detergents and related products, as a component of specialty chemicals manufacturing, may involve the use of materials categorized as hazardous, and may also generate wastes categorized as hazardous. There are extensive regulatory controls on hazardous wastes in Ontario, both in terms of federal and provincial requirements.

Key legislation in Canada covering hazardous materials is the federal *Transportation of Dangerous Goods Act* and Regulation. This Act only applies directly to the transportation of materials across boundaries and is not directly environmental legislation (i.e. it does not contain references to releases to the environment or environmental effects). However, it provides a framework for controlling the transport of hazardous materials, including by inference, hazardous wastes which are covered in provincial laws, such as the *Ontario Dangerous Goods Transportation Act*. The definitions contained in these Acts of what constitutes hazardous materials, including flammability/ignitability, toxicity, corrosiveness, and reactive or explosive nature, are also used to define hazardous wastes.

The handling of hazardous materials, by inference including hazardous wastes, is also relevant in terms of occupational health and safety and Workplace Hazardous Materials Information Systems (WHMIS) requirements. These limits and requirements are outlined in Regulation 654 (Control of Exposure to Biological or Chemical Agents) and Regulation 860 (WHIMS) under the *Ontario Occupational Health and Safety Act.*

The main legislative mechanism in Ontario for the specific control of hazardous wastes is Regulation 347 (Waste Management General) under the *Ontario Environmental Protection Act.*

In addition to the general categories of hazardous materials described above, Regulation 347 defines a series of categories of materials that are specifically designated as hazardous wastes, as follows:

- "Hazardous industrial wastes";
- "Acute hazardous waste chemicals";
- "Hazardous waste chemicals"; and
- "Severely toxic wastes".

For each designated category, materials included are specifically listed in the regulation. For example, ethylene oxide, which is used in the manufacture of certain surfactants, is included as a hazardous waste chemical. Other potentially materials commonly used in soap and detergents include aromatic solvent and chlorinated organic solvent materials. Polychlorinated biphenols (PCBs), as defined under Regulation 362 (Waste Management -PCBs) are also specifically included as hazardous wastes. Specific requirements for handling of PCB's are outlined in Regulation 362.

Regulation 347 specifically requires the registration of all sites generating hazardous wastes as "generators". It provides prohibitions on how hazardous wastes may be handled or disposed, and requires the use of a manifest system for the transfer of any hazardous wastes, in order to track the chain of custody from generator to ultimate disposal.

9.5 SUBSTANCE CONTROL REGULATIONS

The Federal *Canadian Environmental Protection Act* (CEPA) is relevant to soap, detergents and related products manufacturing, in that it controls specific substances and products for "toxicity" and deleterious effects on the environment, rather than the control of wastes or discharges. As such, a series of conditional lists of substances have been developed under CEPA, including:

- *Domestic Substances List.* In general the manufacture, import, or sale of a given substance is prohibited unless it is included on the Domestic Substances List. If not on the list, sufficient testing or documentation is required to demonstrate satisfactorily that the given material is not "toxic".
- *Non-Domestic Substances List.* This list includes substances introduced into commercial use elsewhere in the world but not Canada, and not on the Domestic Substances List. If a manufacturer wants to introduce such substances into Canada, it may would have to fulfill the New Substances Notification Regulations, described below.
- *Priority Substances List.* This list includes designated substances given a priority for assessment of toxicity.
- *List of Toxic Substances.* This list includes substances designated as toxic. Controls may be applied to such substances to protect health or the environment.
- *List of Prohibited Substances.* The use in Canada or import of these substances may be prohibited.
- *List of Toxic Substances Requiring Export or Import Notification.* Substances on this list require prior notification of intent to export or import.
- *List of Hazardous Wastes Requiring Export or Import Notification.* Wastes on this list require prior notification of intent to export or import.

The status of substances may be shifted from one list to another, based on updated assessments and information. A regulation also exists under CEPA for

New Substances Notification. This Regulation outlines notification requirements, and associated information, for new substances that are not on the Domestic Substances List.

One substance control regulation under CEPA is specific to the soap, detergents and related products industry. This is the Phosphorus Concentration Regulation. This regulation specifies that the concentration of phosphorus in any laundry detergent shall not exceed 5.0 percent by weight as expressed as phosphorus pentoxide, or 2.2 percent by weight expressed as elemental phosphorus.

Another regulatory initiative under the authority of CEPA is the National Pollutant Release Inventory (NPRI), which was initiated in 1993. NPRI is a computerized inventory system intended to document the annual use, quantities and potential releases to the environment by industries of 178 specified chemical substances. NPRI is very similar to the Toxic Release Inventory (TRI) implemented in the US in 1986 by the Environmental Protection Agency (EPA). The purpose of NPRI is to both measure current potential releases and encourage reductions in the use of these chemicals.

Under the Federal *Food and Drugs Act*, the definition of "drugs" includes substances or mixtures of substances used in disinfection in premises in which food is manufactured, prepared or kept. This definition is relevant to certain products from the soap, detergents and related products industry, although application to hard surface disinfectants is currently under review. Implications for products that fall under the definition of "drugs" include the following:

- Product registration is required, including the assignment of a Drug Identification Number (DIN), as required by the Food and Drug Regulations;
- Fees associated with the assignment and maintenance of a DIN may be applicable, as specified under the Drug Evaluation Fees Regulations;
- Manufacturing procedure standards may be required, such as adherence to Good Manufacturing Practices; and
- Packaging and labelling standards may be required.

Under the Federal *Pest Control Products Act*, the definition of pest control products includes substances used directly or indicated for control of pests, including enhancing or modifying substances, and active ingredients used in manufacture. This definition may apply to certain products from the soap, detergent and related products industry, such as insecticidal soap. Implications for products that fall under the definition of "control products" include: registration of products; manufacturing standards; packaging; and labelling. Such products also have implications with regard to wastes generated and effluent discharges are described earlier.

10.0 OTHER HELPFUL INFORMATION

10.1 INTRODUCTION TO ENVIRONMENTAL MANAGEMENT SYSTEMS AND ISO 14000

Although variations exist regarding what is precisely involved by the term "environmental management", it is generally taken to mean "an organization considering environmental effects and impacts in its activities, actions and decisions."[22] By extension, environmental management systems (EMS) involve the internal organizational structures and procedures by which a business takes environment implications into account.

An EMS forms one part of an organization's environmental strategy. Objectives of environmental strategies may include:[23]

- Recognizing global environmental trends early and modifying the company's plans accordingly;
- Increasing stakeholder satisfaction and confidence;
- Improving long-term corporate profitability;
- Seeking competitive advantage by minimizing environmental impacts through improved design of products, packages and processes;
- Adopting a proactive, creative approach to ecological challenges through the company;
- Reducing costs by taking advantage of eco-friendly technologies and through energy and resource conservation;
- Minimizing risks arising from management of product liabilities, sudden changes in legal norms, sudden increases in ecology-motivated consumer demands, or changes in comparative risk assessments; and
- Ensuring that the company meets all compliance and due diligence requirements.

One methodology for achieving an effective EMS is through the use of the ISO 14000 standards developed by the International Organization for Standardization (ISO), based in Geneva. The ISO began after the Second World War as a non-governmental, international organization. Its purpose has been the development of voluntary international standards, across a wide variety of fields. As a non-governmental body, ISO has no authority to impose standards.

The application of ISO standards has typically been based on a registration procedure. Any organization can obtain and apply ISO standards as desired. However, by applying a prescribed auditing procedure by authorized personnel,

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22 Professor Nigel Roome, Director of the Haub Program in Business and the Environment, Schulich School of Business, York University, Toronto.

23 Society of Management Accountants of Canada. 1995. Management Accounting Guideline 37: Implementing Corporate Environmental Strategies.

an organization can be "registered", and thus be officially certified as meeting the requirements of a specific standard.

During the 1980's the ISO undertook the development of an organizational management-related standard for quality. This was completed in 1987 and was designated as the ISO 9000 series of standards. These quality standards became extremely popular on an international basis. A large number of companies either adopted, emulated or moved toward the ISO 9000 approach for their production or service operations. Registration was accepted as an indicator that the company would provide a product or service of consistent quality.

At the same time as the successful quality standard was being implemented, ISO began to consider the application of standards to environmental management. This was undertaken in response to a variety of international initiatives, including the report of the Bruntlund Commission and the signing of the Montreal Protocol, which signalled an increased priority for environmental issues. After initial consultations, ISO committed at the 1992 United Nations Conference on Environment and Development (Rio Conference) to create a series of environmental standards, namely the ISO 14000 series.

The development of specific standards has been on-going since 1992, with standards grouped under six major categories:

- Environmental Management Systems;
- Environmental Auditing;
- Environmental Labelling;
- Environmental Performance Evaluation;
- Life-Cycle Assessment; and
- Environmental Aspects in Product Standards.

A summary listing of current and proposed ISO 14000 Standards is presented in Exhibit 10.1.[24] These standards can be broken down into essentially two application components, illustrated in Exhibit 10.2,[25] and summarized as follows:

- Those standards dealing with organizational performance and evaluation (process aspects); and
- Those standards dealing with product evaluation (product aspects).

Both groupings of standards are applicable to the soap and detergents sector. However, the product evaluation standards are likely to be most important, given that the organizational focus of the sector tends to be on products rather than processes, and that many of the environmental implications of the sector are strongly downstream-oriented, when products are consumed by users.

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24 Based on Dixon, JL. and J. Kraegel. 1996. The ISO 14000 Series: Improving Environmental Performance. Engineering Dimensions. Vol 17: No 2 (March/April): p54-55.

25 Cascio, J., G. Woodside, and P. Mitchell. 1996. ISO 14000 Guide. McGraw-Hill.

EXHIBIT 10.1: Summary Information on ISO 14000 Standards

ISO = International Organization for Standardization

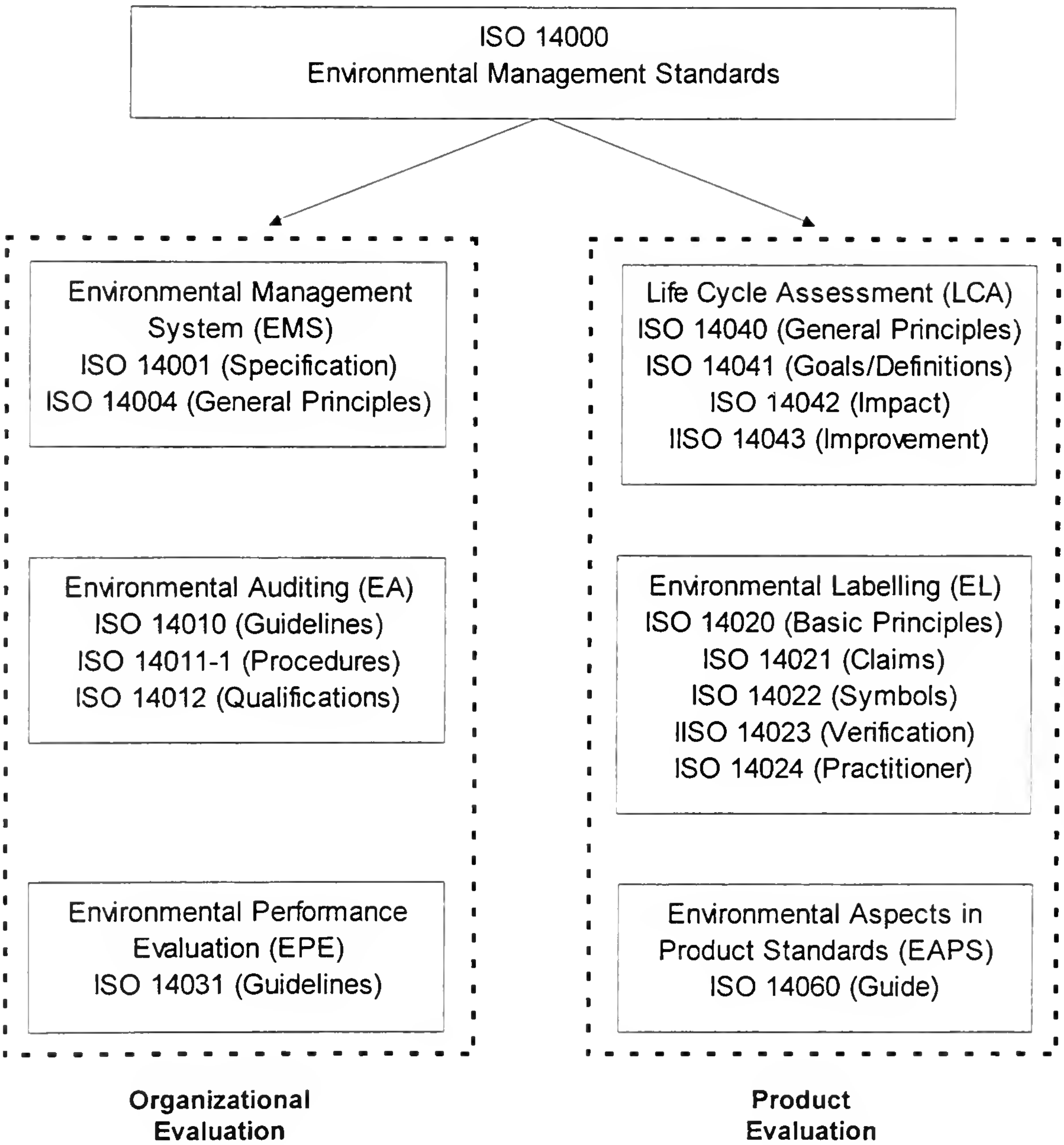
ISO 14000 standards under development will involve six elements:

Environmental Management Systems	EMS
Environmental Auditing	EA
Environmental Labelling	EL
Environmental Performance Evaluations	
Life-Cycle Analysis	LCA
Environmental Aspects in Product Standards	

ISO 14000 STANDARD SERIES

NUMBER	STANDARD TITLE
14001	EMS - Specification with Guidance for Use
14004	EMS - General Guidelines on Principles, Systems and Supporting Techniques
14010	EA - General Principles of Environmental Auditing
14011.1	EA - Audit Procedure Part 1: Auditing of EMS
14012	EA - Qualification Criteria for Environmental Auditors
14014	EA - Initial Reviews
14015	EA - Environmental Site Assessments
14020	EL - General Principles
14021	EL - Self-Declaration: Environmental Claims, Terms, and Definitions
14022	EL - Self-Declaration, Environmental Claims - Symbols
14023	EL - Self-Declaration, Environmental Claims - Testing and Verification Methodologies
14024	EL - Practitioner Programs: General Principles, Practices and Certification Procedures of Multiple Criteria Programs.
14025	Type III Environmental Labelling
14031	Environmental Performance Evaluation
14040	LCA - General Principles and Guidelines
14041	LCA - Inventory Analysis
14042	LCA - Impact Assessment
14043	LCA - Interpretation
14050	Terms and Definitions
14060	Guide for the Inclusion of Environmental Aspects in Product Standards

EXHIBIT 10.2: Organizational and Product Aspects of ISO 14000



10.2 RESPONSIBLE CARE® PROGRAM

Responsible Care® is a set of initiatives developed by the Canadian chemical industry, and now being adopted by chemical companies world-wide. *Responsible Care®* is a management approach to continuous improvement comprised of guiding principles and six codes of practice related to:

- Community awareness and emergency response;
- Research and development;
- Manufacturing;
- Transportation;
- Distribution; and
- Hazardous waste management.

The codes of practice encompass 152 elements that defined what is expected of a participating company, including criteria for evaluating progress. The codes require member companies to implement specific procedures designed to protect employees, the community and the environment.

In addition to the provision of information, the codes include emergency procedures which must be field-tested and updated on a regular basis. The codes also require members to meet or exceed both the letter and spirit of all applicable laws at each stage of operations. If a member company's activities cannot be done in conformance with the applicable code, the code requires that the company not carry out that activity.

Further information regarding *Responsible Care®* can be obtained from:

The Canadian Chemical Producers' Association (CCPA)
Suite 805, 350 Sparks Street, Ottawa, Ontario K1R 7S8
Telephone: (613) 237-6215

10.3 INDUSTRY CONSERVATION BRANCH DATA ON IMPROVEMENTS

The Industry Conservation Branch (ICB) of the MOE provides assistance to Ontario industries in a variety of forms, including the following programs:

- Current Sector Guides;
- Past Industrial Energy Services Program (IESP); and
- Past Green Industry Analyses and Retrofits (GIAR) program.

Through the operation of these specific programs, useful information on resource conservation and pollution prevention in industrial operations has been developed, as summarized in the following sections.

10.3.1 Other Sector Guides

This guide on soap, detergents and related products manufacturing is one of a series published by the Industry Conservation Branch. Guides for other sectors may contain information useful to the soap and detergents sector.

Soap, detergents and related products are intended to be used, whether by industrial, institutional or consumer users. Ultimately, these products are discharged to sewer, and as such, normally would be directed to a municipal wastewater treatment system, where they represent a contributing load. A separate sector guide, entitled "**Guide to Resource Conservation and Cost Savings Opportunities in the Water and Wastewater Treatment Sector**" is available.

A separate sector guide was also prepared for another part of the Formulated Products and Specialty Chemicals industry. This guide is entitled "**Guide to Resource Conservation and Cost Savings Opportunities in the Adhesives, Paints and Coatings Sector.**" Given similarities of some process operations, the opportunities presented in this guide may be applied to the soap and detergent sector.

Several other guides have been prepared for industries that are significant users of cleaning products. The guides include the following:

- "**Guide to Resource Conservation and Cost Savings Opportunities in the Meat and Poultry Sector**";
- "**Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Industry**"; and
- "**Guide to Resource Conservation and Cost Savings Opportunities in the Food Services Sector**".

Other sectors for which guides have been published are automotive parts manufacturing, plastics manufacturing, plastics reprocessing, food services and office buildings.

Copies of these guides can be obtained from the MOE through the contacts listed on page iii of this guide.

10.3.2 Audit Data for Selected Soap and Detergent Energy Improvements

Energy Analyses have been conducted at a variety of soap, detergents and related products processing plants in Ontario since 1987. Aggregate data was available for 103 selected improvement projects recommended at plants within the soap and detergent sector. The aggregate estimated capital cost was approximately \$2.7 million, with aggregate annual savings of approximately \$1.4 million and resulting simple payback of 1.9 years.

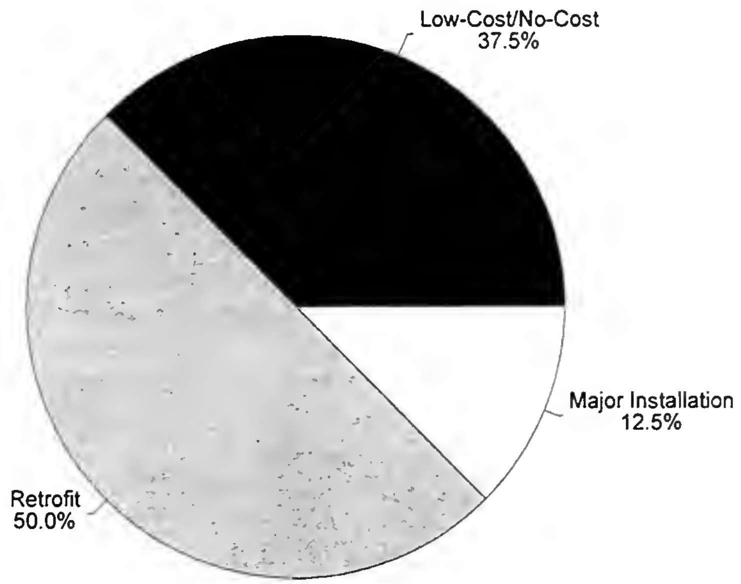
Based on the results of these audits, information on energy improvement projects by technology type are summarized as follows:

- Exhibit 10.3 presents a breakdown of projects by size, including: (1) Low-cost/no-cost (<$5,000); (2) Retrofit ($5,000 to $50,000); and (3) Major projects (>$50,000). A breakdown of probable capital expenditure, annual energy savings and resulting pay backs is also provided.
- Exhibit 10.4 presents aggregated estimates of capital expenditures and annual energy savings derived for five major technology categories, which represent approximately 75% of all identified capital costs and savings. These five categories are: (1) Equipment upgrade or replacement; (2) Electrical efficiency improvements; (3) Heat recovery from boilers/flue gases; (4) Boiler/combustion system upgrades; and (5) Process/effluent waste heat recovery.

More specific summaries of the project types, capital costs and savings identified are provided in Appendix V.

EXHIBIT 10.3: Breakdown of Selected IESP Energy Improvement Projects by Size

Proportion of Projects by Size



Aggregate Capital Costs and Annual Savings by Size

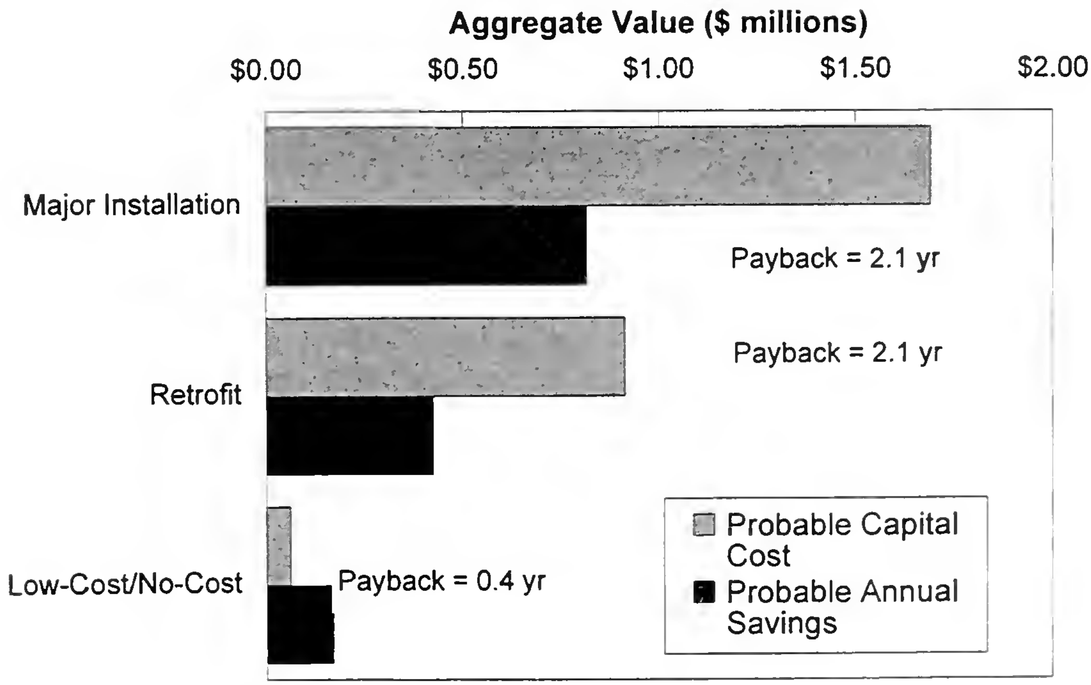
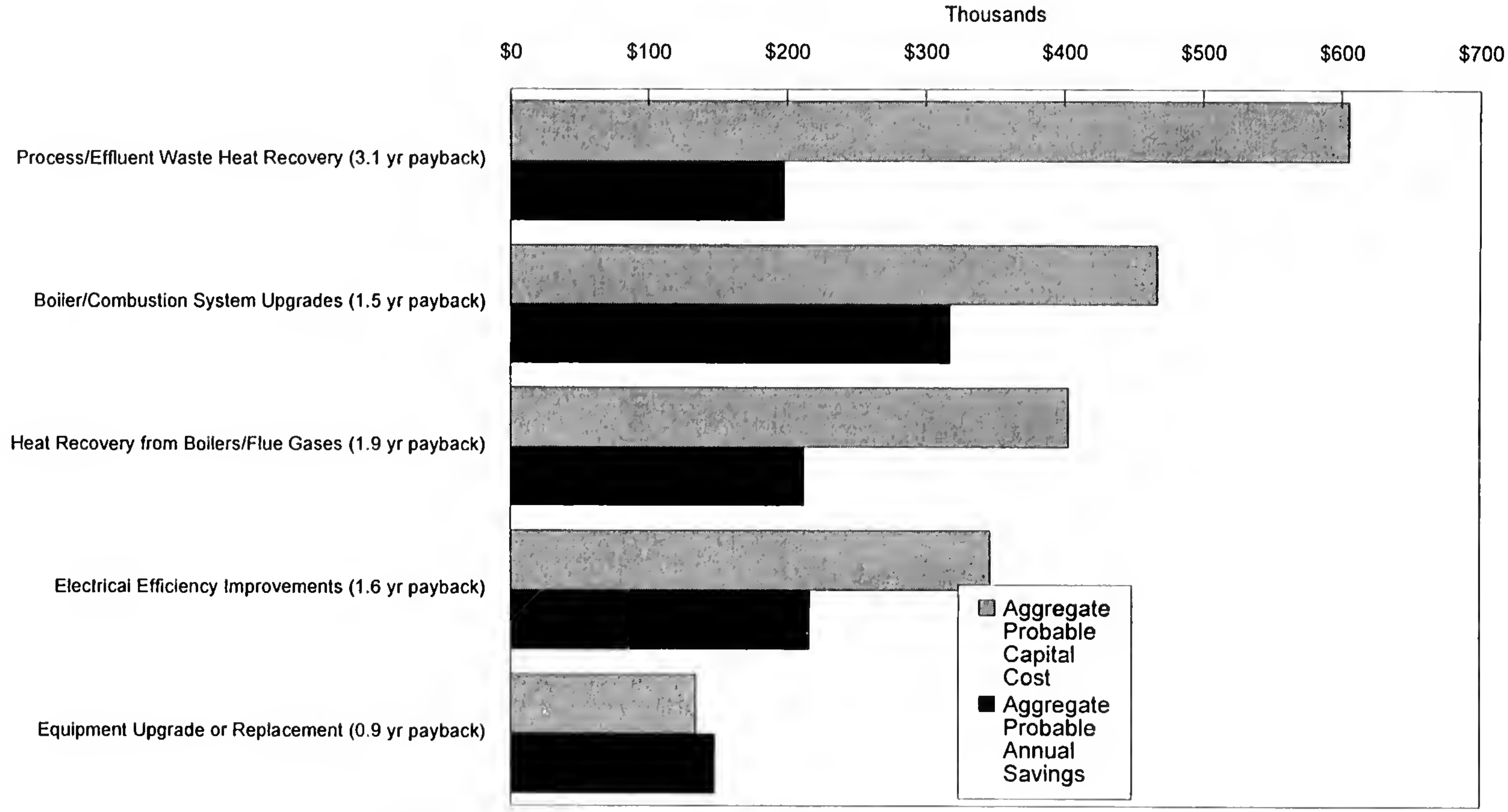


EXHIBIT 10.4: Aggregate Capital Cost and Savings for Major Categories of Savings Projects
(Five Categories Represent 75% of Cost and Savings Identified)



10.4 DIRECTORIES AND GUIDES

Reference directories and guides relevant to soap and detergent processing plants available from other organizations are described in the following sections.

10.4.1 Ontario Environment Business Directory, 1998 Edition

This directory provides contact information and description of products, technologies and services for 500 environmental businesses in Ontario. The directory is indexed by the following market segments:

-air pollution prevention and control
-energy efficiency/renewables
-environmental contracting and engineering
-environmental monitoring, analysis and assessment
-noise/vibration abatement
-site remediation
-solid and hazardous waste management
-water and wastewater treatment/water conservation

For copies of the Ontario Environment Business Directory contact the Green Industry Office at (416) 323-4597, fax (416) 323-4436 or email defoebr@ene.gov.on.ca

10.4.2 Natural Resources Canada

- Natural Resources Canada. 1994. CEMET Resource Catalogue: List and Description of Available Energy Efficiency Products and Services.
- Natural Resources Canada. A Manager's Guide to Creating Awareness of Energy Efficiency. Efficiency and Alternative Energy Program.
- Natural Resources Canada. 1994. Technical Information. Efficiency and Alternative Energy Program.
- Canadian Industry Program for Energy Conservation. CIPEC Energy Efficiency Planning and Management Guide.

10.4.3 Pollution Prevention Guidance Documents

- Ontario Ministry of Environment and Energy. 1993. Pollution Prevention Planning: Guidance Document and Workbook. PIBS 2586E. ISBN 0-7778-1441-2.
- Canadian Standards Associations. 1994. Guideline for Pollution Prevention. Z754-94.
- Canadian Standards Associations. 1994. Environmentally Responsible Procurement. Z766-94.
- Ontario Waste Management Corporation (OMWC). 1993. Industrial Waste Audit and Reduction Manual. 3rd ed.
- Rutgers (State University of New Jersey), Office of Industrial Productivity and Energy Assessment. Self-Assessment Workbook for Small Manufacturers.

10.4.4 Environmental Approvals Guidance Documents

- Ontario Ministry of Environment and Energy, Approval's Branch. 1994. Guide for Applying for Approval of Industrial Sewage Works. November.
- Ontario Ministry of Environment and Energy, Approval's Branch. 1994. Guide for Applying for Approval (Air). November.

10.5 ADVANCED ANALYSIS METHODOLOGIES

A comprehensive approach to analysing pollution prevention, and water and energy use reduction is essential in the case of complex processes. A variety of advanced analysis methodologies are available for this purpose, including the following:

- Energy Process Integration or *Energy Pinch* analysis, which can be used to determine thermodynamically optimal energy recovery in complex facilities;
- *Mass Pinch* analysis, which is an analogy of Energy Pinch analysis and can be used to assist in materials-use minimization; and
- Micro-Level Analysis of emissions (MLA), which is an augmented material-balance approach for the systematic evaluation of emissions from process operations.

These analysis methodologies are described in more detail in Appendix IV.

10.6 TECHNOLOGY AND PROGRAM WEBSITES

- Ontario Minstry of Environment: www.ene.gov.on.ca;
- Environment Canada (Green Lane): www.doe.ca;
- Natural Resources Canada, Energy Efficiency Branch: www.eeb-dee.nrcan.gc.ca;
- US Environmental Protection Agency (Environ$ense): www.epa.gov/envirosense;
- US Office of Industrial Productivity and Energy Assessment: oipea-www.rutgers.edu;
- Canadian Committee for Electrotechnologies: www.cce.qc.ca;
- Gas Technology Canada: www.gtc.ca;
- Centre for the Analysis and Dissemination of Demonstrated Energy Technologies: caddet-ee.org;
- Canadian Manufacturers of Chemical Specialties Association: cmcs.org;
- Voluntary Challenge and Registry (VCR): www.vcr-mcr.ca; and
- The Env./Industry Virtual Office: www.virtualoffice.ic.gc.ca.

APPENDIX I - GLOSSARY

I.1 ACRONYMS

BOD	Biological Oxygen Demand
CADDET	Centre for the Analysis and Dissemination of Demonstrated Energy Technologies
CEPA	Canadian Environmental Protection Act
CCME	Canadian Council of Ministers of the Environment
CMCS	Canadian Manufacturers of Chemical Specialties
DIN	Drug Identification Number
EPA	US Environmental Protection Agency
FPSC	Formulated Products and Specialty Chemicals
GIAR	Green Industry Analysis & Retrofits
HEM	High Efficiency Machine (Washing Machine)
IESP	Industrial Energy Services Program
ISO	International Organization for Standardization
LAS	Linear Alkyl Sulphonate
MOE	Ontario Ministry of the Environment
MOEE	Ontario Ministry of Environment and Energy
MOU	Memorandum of Understanding
NAPP	National Packaging Protocol
NPRI	National Pollutant Release Inventory
PST	Private Sewage Treatment
SIC	Standard Industry Classification
SDAC	Soap and Detergent Association of Canada
SSD	Superheated Stream Drying
ThOD	Theoretical Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TRI	Toxic Release Inventory
TSS	Total Suspended Solids
VAM	Vertical Axis Machine (Washing Machine)
WHMIS	Workplace Hazardous Materials Information System

APPENDIX II - BACKGROUND ON SOAP, DETERGENTS AND RELATED PRODUCTS INDUSTRY IN ONTARIO

II.1 SECTOR DEFINITION

The soap and detergents, and related products industry represents a sub-sector under the Formulated Products and Specialty Chemicals (FPSC) market. FPSC represents a collection of products/sub-sectors that forms part of the overall Chemical Industry, however, it is neither discrete nor well identified. Sub-sector statistics and information are scarce, partly because of overlap between Standard Industrial Classification (SIC) categories as defined by Statistics Canada.

For the purpose of this guide, the sector is defined to include activities and establishments involved in the various stages of manufacture of products which are broadly defined to be used for *cleaning* functions, whether for industrial, institutional or consumer application. Major by-products of these manufacturing processes are also included. Definitions of cleaning product terms, including *soap, detergent, surfactant*, etc., are provided in Appendix III of this guide.

Background on the sector definition from various publicly available sources is presented in the following sections.

II.1.1 CANADIAN SIC CATEGORIES AND ACTIVITIES

The sector includes industrial activities and establishments related by similarity of products and processes, rather than business applications, as is reflected primarily by SIC categories. Four major SIC categories are included or partly included within the sector. These are as follows:

Canadian SIC 3761 Soap and Cleaning Compounds

The primary SIC category involved is 3761, Soap and Cleaning Compounds. The principal activities and products manufacturing included under this SIC by Statistics Canada are summarized as follows in alphabetic order:[1]

- Automatic dishwasher detergents, including bottle cleaning compounds;
- Bleaches, granular or liquid;
- Cleaning compounds;
- Cleaning preparations;
- Detergents, synthetic, granular or liquid;
- Fabric softeners;

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1 Definition of principal activities and products included in SIC 3761 from Strategis,at:http://www.strategis.ic.gc.ca/cgi bin/dec/wwwfetch?/sgml/si37610e_pr996.sgml.

- Floor cleaners;
- General purpose cleaners, household or industrial;
- Impregnated metal pads (soap and other detergents);
- Mechanic's hand soap and paste;
- Oven cleaners;
- Rug cleaners;
- Scouring cleansers, including powders, pastes and cakes;
- Soap bars, toilet, laundry and household;
- Soft soap, paste and jelly;
- Toilet bowl cleaners; and
- Waterless hand soaps.

Canadian SIC 3771 Toilet Preparations

A second partially relevant SIC category is 3771, Toilet Preparations. This SIC includes a diverse range of activities and products which are not part of the soap and detergents sector, including cosmetics, perfumes, toothpastes and similar toiletry preparations. However, it includes manufacturing of certain consumer-oriented products that are included:[2]

- Hair shampoo; and
- Other selected soap or cleaning products, such as shaving soaps.

Canadian SIC 3712 Industrial Organic Chemical Industries

A third partially relevant SIC category is 3712, Industrial Organic Chemical Industries. This SIC includes the manufacture of a variety of organic compounds, including:[3]

- Fatty acids and derivatives;
- Organic acids and derivatives; and
- Glycerol (glycerine), crude or refined.

Canadian SIC 3799 Other Chemical Products Industries

A fourth and last partially relevant SIC category is 3799, Other Chemical Products Industries. This SIC represents a polyglot of activities and products that do not readily fit under other categories. Certain manufacturing operations under this SIC including:[4]

- Household disinfectants;
- Certain insecticides, such as insecticidal soaps in which soap is an active ingredient, rather than simply assisting in emulsifying/carrying other active agents;

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2 Definitions of selected activities and products included in SIC 3771 from Strategis, at:http://www.strategis.ic.gc.ca/cgi-bin/dec/wwwfetch?/sgml/si37710e_pr996.sgml.

3 Definitions of selected activities and products included in SIC 3712 from Strategis, at:http://www.strategis.ic.gc.ca/cgi-bin/dec/wwwfetch?/sgml/si37120e_pr996.sgml.

4 Definitions of selected activities and products included in SIC 3799 from Strategis at:http://www.strategis.ic.gc.ca/cgi-bin/dec/wwwfetch?/sgml/si37990e_pr996.sgml.

- Polishing preparations; and
- Surface active agents, or surfactant.

II.1.2 US SIC Categories

Certain sources of information within Canada employ US SIC categories rather than Canadian SIC categories. The grouping of establishments and activities under US SICs is somewhat different. Three categories can be identified in this case:

- US SIC 2841 Soap and other Detergents
- US SIC 2842 Specialty Cleaners
- US SIC 2843 Surface Active Agents

II.2 Number Of Establishments

It is difficult to assess the precise number of Ontario manufacturing establishments involved with soap, detergents and related products. This is because of well known cross-over SIC and categorization uncertainties associated with the FPSC market, as described above.

Based on an evaluation of available data, there are approximately 100 different establishments of primary interest in Ontario, with likely as many as 90 additional establishment with some involvement in the sector. Six major sources of information were employed to identify the number of establishments, summarized as follows:

- Statistics Canada sector-specific information;
- Industry Canada profile of sector;
- Ontario Ministry of Economic Development, Trade and Tourism (MEDTT) profile of sector;
- Frazer's Directory;
- Scott's Directory; and
- Canadian Manufacturers of Chemical Specialties (CMCS) membership listings.

Information provided by each of these sources is summarized as follows:

II.2.1 Statistics Canada Information

Estimates of the number of establishments, based on current Canadian Industry Statistics information (available at www.strategic.gc.ca), are summarized as follows:

SIC CATEGORY	TOTAL ESTABLISHMENTS (1995)	
	CANADA	ONTARIO
SIC 3761	120	50-55
SIC 3771	79	
SIC 3712	66	
SIC 3799	290	

The most relevant group of establishments in the sector are those classified under SIC 3761. There were approximately 120 establishments nationally within this SIC in 1995. Based on historical trend data, Ontario represents approximately 40% to 45% of all establishments nationally within this SIC, translating to approximately 50 to 55 establishments. Additional establishments are present in the other related SIC categories.

II.2.2 INDUSTRY CANADA SECTOR PROFILE

Industry Canada prepared a more detailed sector profile of Soap and Cleaning Compounds manufacturing in 1991. Based on statistical data for the period from 1986 to 1988, approximately 45% of establishments were indicated as being located in Ontario. Nine major establishments, involved in product manufacture, were specifically identified by name, all located in Ontario.

II.2.3 MEDTT SECTOR PROFILE

A recent sector profile of Cleaner and Detergent manufacturing within Ontario was prepared in 1994 by the Ontario Ministry of Economic Development Trade and Tourism (MEDTT). Based on statistical information for the period 1992, 43% of total Canadian establishments (56 of 130 in 1992) were located in Ontario. A total of 40 establishments were specifically identified by name as being principal Ontario producers.

II.2.4 FRAZER'S DIRECTORY

The *Frazer's Directory* is a privately-based directory of suppliers of products, organized by product type. This directory is, of course, not compulsory, but includes designation of companies by the types of products provided. Within relevant product categories, a total of 86 different establishments were identified in the 1995 Frazer's Directory as being located within Ontario, although this group includes both manufacturers and distributors.

II.2.5 Scott's Directory

The *Scott's Directory* is a privately-based directory of firms involved in manufacturing. Unlike Statistics Canada-based information, this directory does not require compulsory registration, and thus not all firms may be included. This directory is also grouped according to US rather than Canadian SIC categories. The three categories are described in section II.1.2. Based on data from the latest directory database:

- A total of 98 establishments are listed in the primary SIC categorizations.
- A total of 190 establishments are listed with a relevant SIC as one of their categorizations (primary or secondary SIC).

II.2.6 CMCS Membership

The membership list of the Canadian Manufacturers of Chemical Specialities (CMCS), which includes the Soap and Detergent Association of Canada (SDAC), is publicly available (refer to www.cmcs.org). Currently, 75 firms are listed as members of CMCS, of which 56 are likely participants located in Ontario.

II.3 ECONOMIC STATUS

The soap and detergents, and related products sector in Ontario currently represents total manufacturing shipments of approximately $1.5 billion and total employment of approximately 4,000 within the province. This sector is economically important in two respects:

- Sector within Canada represents a significant component of the overall national chemical industry. This is similarly true in Ontario, where it represents a significant component of the provincial chemical industry.
- Ontario represents a substantial proportion of the sector on a national basis.

The soap, detergent and related products sector also manufactures products with a relatively high proportion of value-add, consistently representing just over 50% of the value of manufacturing shipments. As noted earlier, the analysis is limited because of the problem of overlapping SICs.

More detail on the derivation of data is presented in the following sections.

II.3.1 ECONOMIC PERFORMANCE DATA

The SIC 3761 (Soap and Detergent) is a major component of this sector. In 1992, this SIC represented approximately 7%, both in terms of total manufacturing shipments and total estimated domestic market for the overall chemical industry in Canada, as illustrated in Exhibit A.1.

In 1992, Canadian manufacturing shipments for the overall chemical industry totalled approximately $22 billion, with the overall domestic market (shipments plus imports less exports) totalling approximately $24 billion. Canadian domestic manufacturing shipments for SIC 3761 in 1992 were approximately $1.7 billion, while total estimated domestic market was approximately $1.8 billion. In 1992, only two major SIC groups within the Canadian chemical industry were net exporters (i.e. manufacturing shipments greater than total domestic market), these being Industrial Inorganic Chemicals (3711) and Chemical Fertilizers (3721). Of all the remaining SIC groups, Soap and Detergent (3761) had the lowest percentage deficiency difference between total domestic market and total domestic manufacturing shipments.

In 1995, the Ontario Ministerial Advisory Committee on Chemicals (MAC Chem), through the auspices of MEDTT prepared a major review of the Ontario Formulated Products and Specialty Chemicals (FPSC) Industry, entitled "Catalyst for Change." The FPSC market represents a significant subset of the overall chemical industry, although not one that is discretely identified nor regularly reported as a group by Statistics Canada. National-based data from Statistics Canada for 1992 was employed as part of the MAC Chem report to estimate the FPSC market. The relationship the FPSC market values to the overall chemical industry for 1992 may be summarized as follows:

- Total FPSC domestic manufacturing shipments in 1992 were approximately $8.2 billion, or roughly 38% of total chemical industry shipments.
- Total FPSC domestic market in 1992 was approximately $11.9 billion, or roughly 48% of the overall domestic market for chemicals in Canada.

As illustrated in Exhibit A.2, SIC 3761 (Soap and Detergent) represented approximately 20% of total manufacturing shipments for FPSC, while the SIC represented approximately 15% of the total domestic market for FPSC in 1992. Unfortunately, no more recent data is available regarding the overall FPSC.

More recent data is, however, available for the overall chemical industry. In 1995, as illustrated in Exhibit A.3, SIC 3761 (Soap and Detergent) represented approximately 5%, both in terms of total manufacturing shipments and total estimated domestic market for the overall chemical industry in Canada. In 1995, Canadian manufacturing shipments for the overall chemical industry totalled approximately $28 billion, with the overall domestic market totalling approximately $33 billion. Canadian domestic manufacturing shipments for SIC 3761 in 1995 were approximately $1.6 billion, while total estimated domestic market was approximately $1.7 billion. Still in 1995, only two major SIC groups within the Canadian chemical industry were net exporters (still SICs 3711 and 3721). The relative position of SIC 3761, however, had slipped considerably from 1992. In 1995 both SIC 3731 (Plastics and Synthetic Resins) and SIC 3712 (Industrial Organic Chemicals) had moved ahead of SIC 3761, having lower proportional deficiencies between the values of manufacturing shipments and domestic market.

Historical tracks of total manufacturing shipments and total domestic market for SIC 3761 on a national basis are presented in Exhibit A.4. As indicated, the gap between the two parameters developed since approximately 1988, although relatively stabilized since approximately 1992.

EXHIBIT A.1: Total Chemical Industry in Canada for 1992

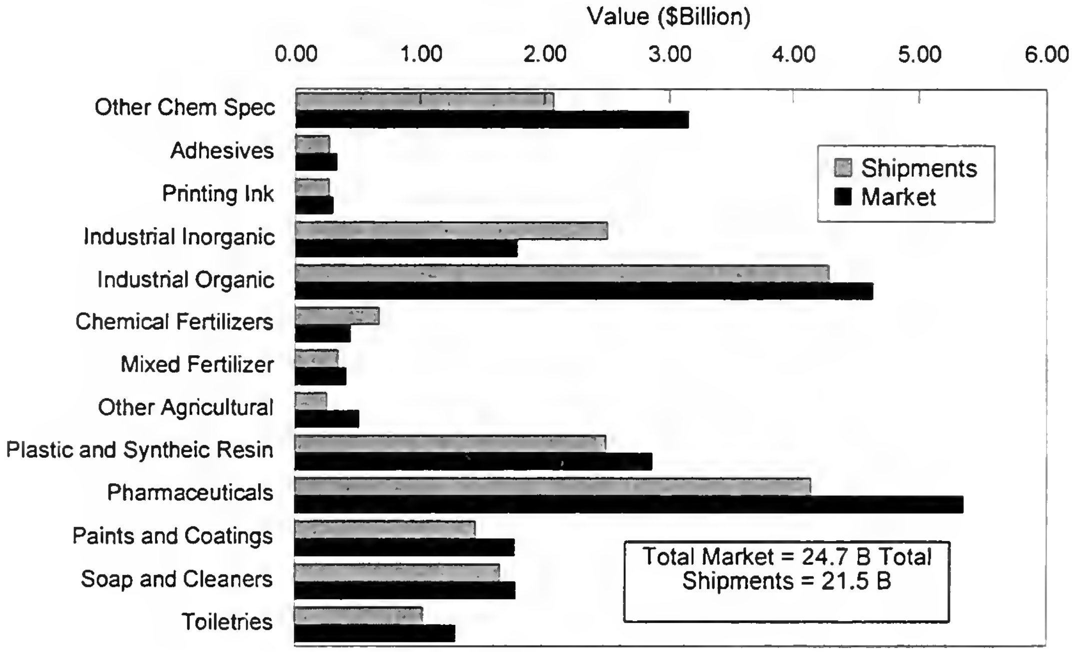


EXHIBIT A.2: Formulated Products & Specialty Chemicals in Canada for 1992

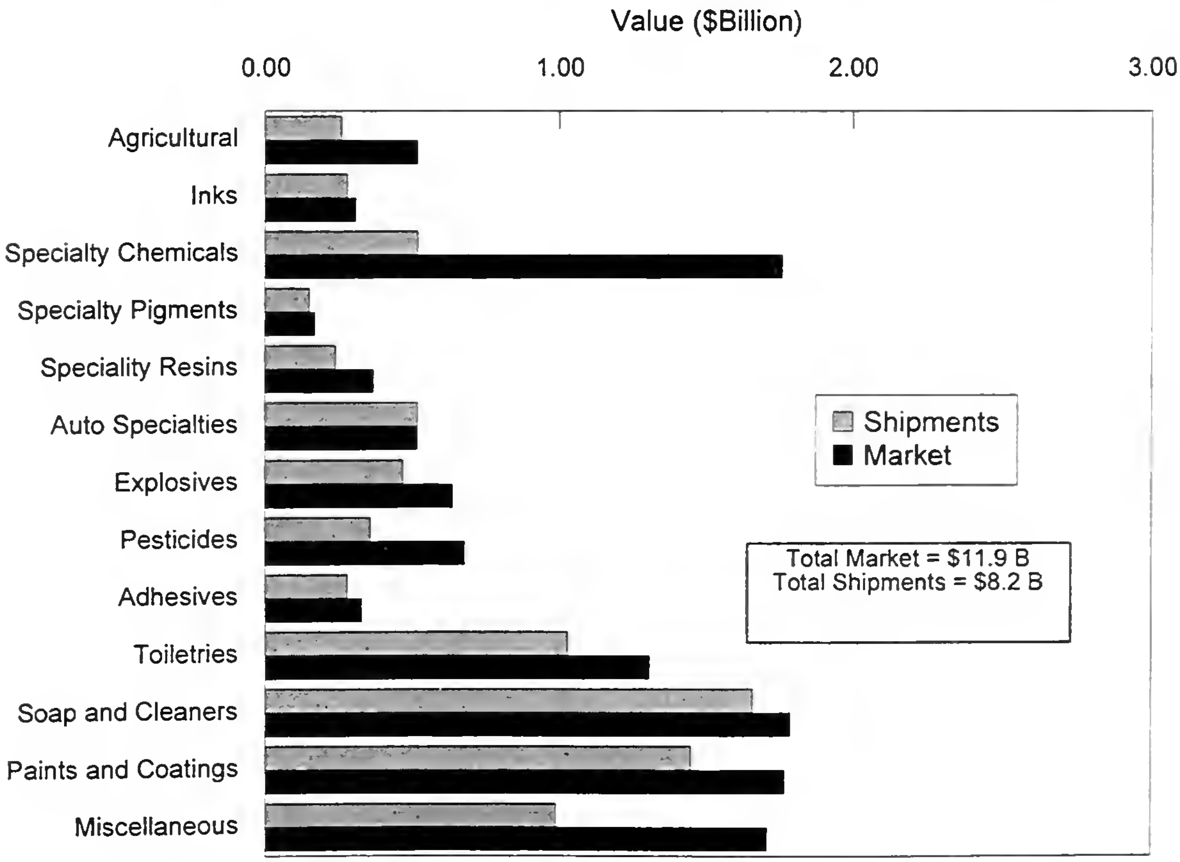


EXHIBIT A.3: Total Chemical Industry in Canada for 1995

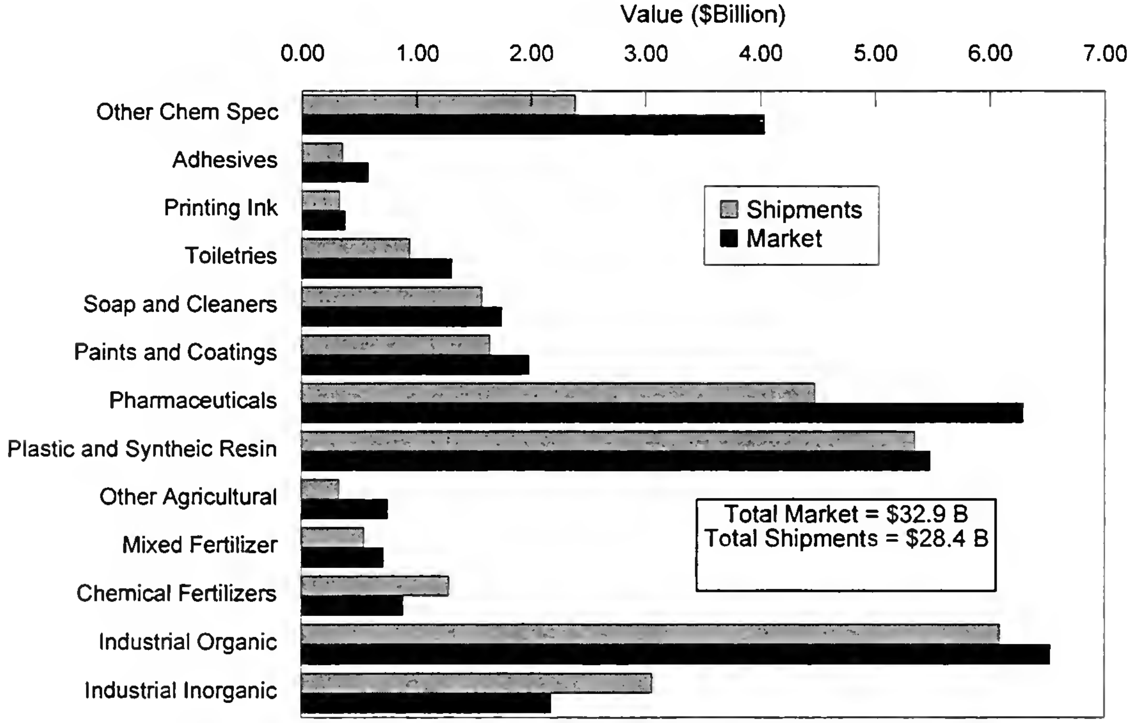
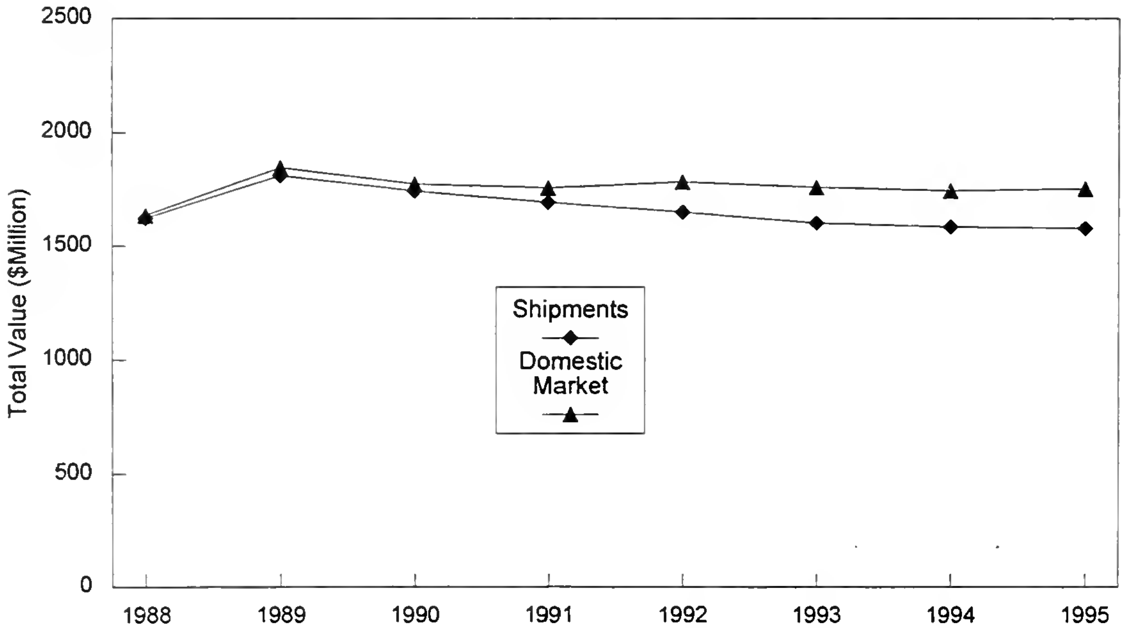


EXHIBIT A.4: Historical Track of SIC 3761 Market and Shipments



A sector analysis of the Cleaners and Detergents Industry (i.e. SIC 3761) was prepared in 1994 by MEDTT. As part of this work, the proportion of the total national sector represented by Ontario was determined for the years 1982 though 1992, as follows:

- Ontario consistently represented approximately 43% of all manufacturing establishments within Canada.
- Ontario consistently represented approximately 87% of the value of all manufacturing shipments within Canada.
- Ontario consistently represented approximately 80% of total manufacturing employment within Canada.

No further regional breakdown data is available via Statistics Canada for more recent years. Assuming that the above trends have remained consistent, projections of the Ontario component of SIC 3761 can be estimated as follows:

- Manufacturing establishment for SIC 3761 approximately 52 in 1995;
- Manufacturing shipments for SIC 3761 approximately $1.3 billion in 1995; and
- Manufacturing employment for SIC 3761 approximately 3,300 in 1995.

Current employment within the target sector within Ontario was further evaluated by adding together reported employment data for all identified firms using the Scott's Directory. Based on this evaluation, total employment is in the range of 4,000 to 5,000 for the entire sector. Direct manufacturing employment would be lower.

Data from the 1992 US Census of Manufactures (at www.census.gov) is also useful in assessing the relative proportion of respective industries to populations in the two countries, given the uncertainties associated with quantifying the sector in Ontario. The 1992 data for the three US SICs is summarized as follows:

SIC	DESCRIPTION	EMPLOYEES	SHIPMENTS
2841	Soap and other Detergents	32,900	$14.8 billion USD
2842	Specialty Cleaners	22,00	$6.7 billion USD
2843	Surface Active Agents	8,200	$2.9 billion USD
TOTAL		63,100	$24.4 billion USD

Assuming a typical 10:1 ratio based on population, the US data suggests total Canadian **manufacturing shipments** for the sector to be in the range of $2 to $3 billion, and thus **for Ontario in the range of $1.5 to $2.5 billion**, and **total employment** for the sector of 6,000 to 7,000 in Canada, and **5,000 to 5,500 in Ontario**. Given that Canada has not been as strong in specialty product areas, such projections from US data can be viewed more as upper limits.

II.3.2 MANUFACTURING VALUE-ADD

Soap and cleaners manufacturing has a relatively high value-add when compared to other chemicals production sectors and general manufacturing. Manufacturing value-add as a proportion of annual manufacturing shipments is presented in Exhibit A.5, based on data from Statistics Canada for the years 1991 through 1995, for the following:

- SIC 3761 - Soap and Cleaners Manufacturing;
- SIC 37 - Overall Chemical and Chemical Products Industries; and
- Overall Manufacturing Industries, including SIC 10 through SIC 39.

As can be seen from this data, the Soap and Cleaners SIC exhibits value-add that is consistently higher than the aggregate for either the overall Chemical industry or all manufacturing industries within Canada. Approximately average five year values are as follows:

- Value-add of 51% for SIC 3761 - Soap and Cleaners Manufacturing;
- Value-add of 48% for SIC 37 - Overall Chemical and Chemical Products Industries; and
- Value-add of 40% for all Manufacturing Industries, including SIC 10 through 39.

A histogram of proportion of value-add to annual manufacturing shipments is presented in Exhibit A.6 for all two digit SICs. The relative positioning of Soap and Cleaners Manufacturing is also indicated, being approximately at the 74% percentile (i.e. only approximately 26% of industries have a value-add that is higher, while approximately 74% of industries have a value-add that is lower).

EXHIBIT A.5: Historical Value Add of Manufacturing

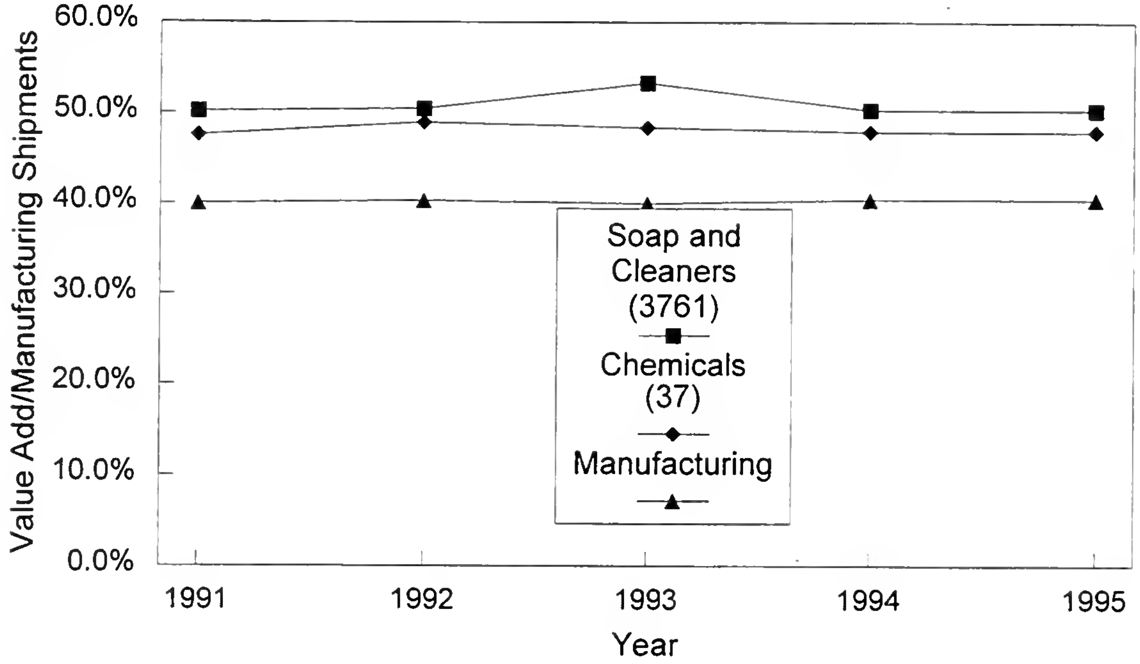
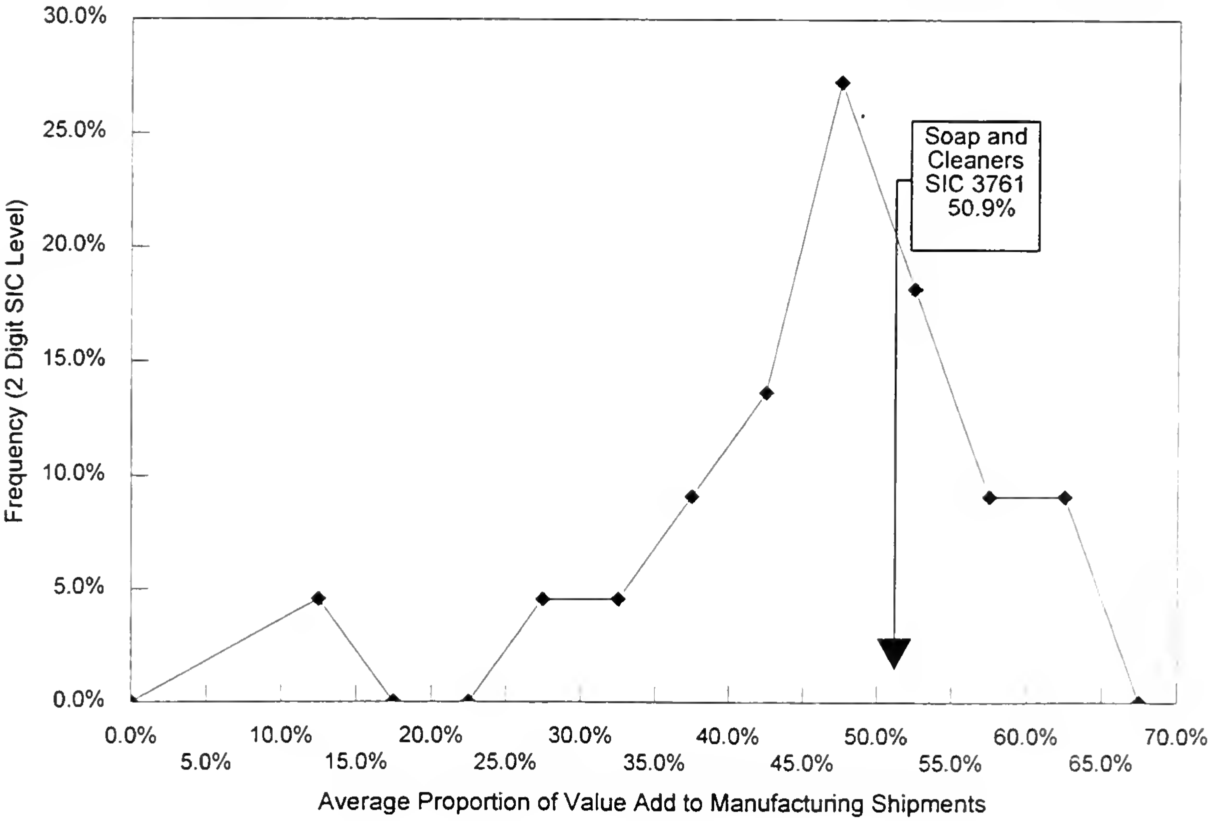


EXHIBIT A.6: Relative Positioning of Soaps and Cleaners for Value Add



APPENDIX III - BACKGROUND ON INGREDIENTS FOR SOAP, DETERGENTS AND RELATED PRODUCTS

III.1 Historical Background On Soap and Detergents

The origins of soap reach far back into antiquity, and, as such, certain traditional aspects have been associated with this product. Soap was first produced nearly 5,000 years ago from a combination of wood ashes and animal fats. In its earliest forms, soap was not, however, used for *washing* purposes, but rather for textiles, to help remove greases from wool so that they would not interfere with application of dyes. Cleanliness and personal hygiene, which now tend to be strongly associated with soap, emerged only relatively recently as desirable human virtues.[1]

Large scale, commercial manufacture of soap only began in the early eighteenth century, prior to which soap production was essentially a cottage industry, involving thousands of small-scale manufacturers. Until 1938, all soaps were produced by batch kettle processes, boiling fats and oils with caustic. Since that time, a variety of continuous industrial soap processes have been available.[2]

The industry was dramatically altered by the introduction of synthetic products. While conventional soaps are still used significantly in facial and body cleansing, such traditional products have always suffered problems associated with calcium and/or magnesium precipitation, particularly in hard water, forming so-called soap "curds" or soap "scum" and reducing cleaning effectiveness. Overcoming calcium precipitation problems and being able to provide more effective cleaning in hard water, especially for clothes laundering, was a prime motivating factor for the development of improved cleaning agents. Synthetic detergents first appeared in the 1920s with the development of commercial synthetic surfactant, and later in the 1940s with the advent of speciality detergent "builders" to enhance surfactant effectiveness.[3] Synthetic surfactant-based detergents rose rapidly in popularity, and have also increased in breadth of application. Synthetic products now dominate in such applications as clothes laundering, dish washing, and shampoos.

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1 For history, refer for example to website: cator.hsc.edu.

2 Osmer, F. 1983. Soap. Kirk Othmer Encyclopedia of Chemical Technology. Wiley-Inter science. Vol. 21. pp162-180.

3 For example refer to website: www.clothesline.com/tide/archive/history.html.

III.2 MAJOR PRODUCT INGREDIENT CATEGORIES

Soap, detergent and related products manufacturing is relatively raw material intensive. These products can range from simple to very complicated chemical formulations. The major categories of ingredients are:

- Surfactants;
- Builders or Sequestering Agents;
- Other Additives; and
- Acid and Caustic Agents.

Each of these major categories is described in the following sections. The chemistry of soap, detergent and related products and their constituent ingredients can be quite complex. As such, there is variability in the classification and designation of the functional chemical ingredients involved. The information provided in the following sections is representative of available literature, but may not be necessarily entirely consistent with any single information source.

III.2.1 SURFACTANTS

The term *surfactant* is a contraction for *surface-active* agent. Surfactant includes conventional soap, synthetic detergents, wetting agents and emulsifiers. A surfactant, when added to water, lowers the surface tension and increases the wetting capabilities of water. Reduced surface tension allows water to: spread and to penetrate fabric or other substances to be cleaned; loosens and removes soil; and emulsifies or suspends soil, especially oily particulate, in a wash solution.[4]

There are four major classes of surfactant: anionic; cationic; non-ionic; and amphoteric. An approximate market breakdown for surfactant on the basis of total product mass and total product revenue value are presented in Exhibit B.1.[5] Anionic surfactant represent the majority of products by mass. At the same time, non-ionic surfactant represent the majority of sales (i.e. value). Compound structures of major commercial surfactant products in each class are provided in Exhibit B.2.[6]

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4 For further definition refer to the Water Quality Association at website location: http://www.wqa.org/WQIS/Glossary/surfact.html.

5 Refer to ___. 1996. Stability Returns to US Surfactant. Chemical Week. Vol. 158, No. 3 (January 24, Issue). p33. see C&EN January 29, 1990 p47.

6 Refer to Aboul-Kassim, T. and B. Simoneit. 1993. Detergents: A Review of the Nature, Chemistry and Behaviour in the Aquatic Environment. Part 1. Chemical Composition and Analytical Techniques. Critical Reviews in Environmental Science and Technology. Vol. 23. No. 4. pp325-376.

EXHIBIT B.1: Breakdown of Surfactant Market by Volume and Value

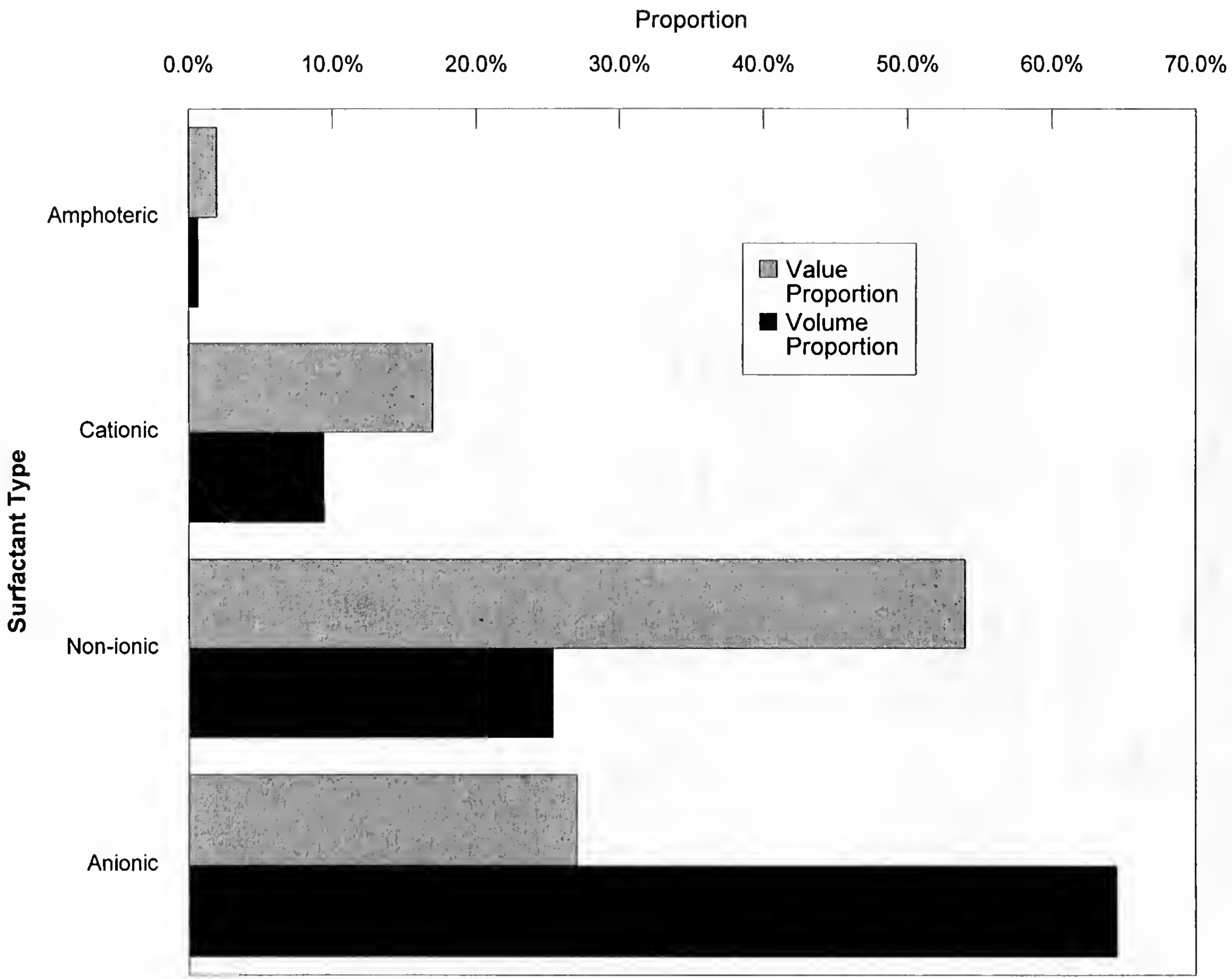
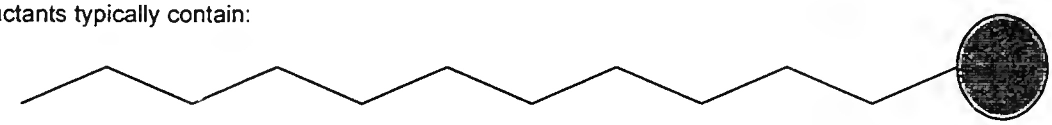


EXHIBIT B.2: Example Structures of Major Surfactant Types

All surfactants typically contain:

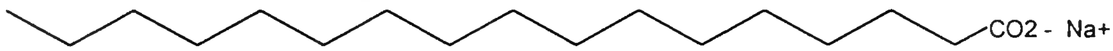


Hydrophobic Moiety (typically long aliphatic hydrocarbon):
- Fatty Acid
- Alkyl Benzene
- Alcohol
- Alkyl Phenol
- Polyoxypropylene

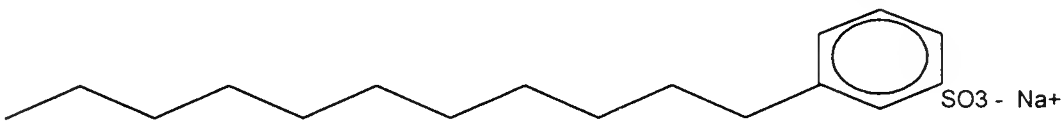
Hydrophilic Moiety:
- Sulfate
- Sulfonate
- Carboxylate
- Quaternary Ammonium
- Sugar
- Polyoxyethylene

Anionic Surfactants Detergency vested in anionic functional group(s).

Soap (e.g. sodium stearate)



Linear Alkyl Benzene Sulfontate (LAS) (e.g. sodium dodecylbenzenesulfonate)



Alkyl Sulfate (AS) (e.g. sodium lauryl sulfate)

Cationic Surfactants Detergency vested in cationic functional group(s).

Quaternary Ammonium (e.g. distearyldimethylammonium chloride)

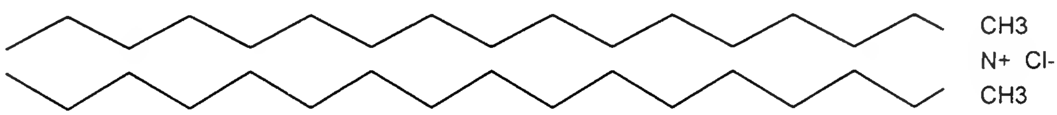
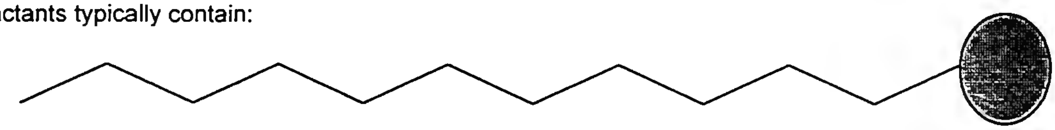


EXHIBIT B.2: Example Structures of Major Surfactant Types ... cont'd

All surfactants typically contain:



Hydrophobic Moiety (typically long aliphatic hydrocarbon):

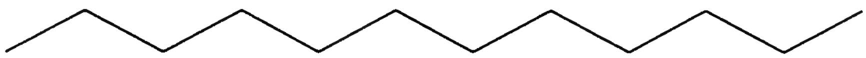
- Fatty Acid
- Alkyl Benzene
- Alcohol
- Alkyl Phenol
- Polyoxypropylene

Hydrophilic Moiety:

- Sulfate
- Sulfonate
- Carboxylate
- Quaternary Ammonium
- Sugar
- Polyoxyethylene

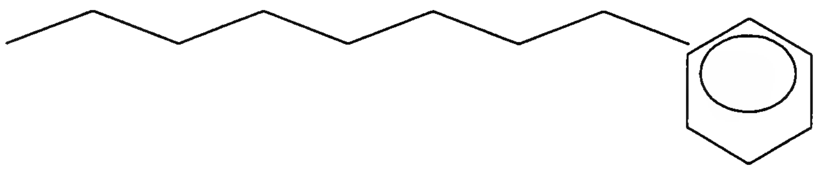
Non-ionic Surfactants Contain no ionic constituents

Alkyl Ethoxylate (AE) (e.g. dodecanol-9-ethoxylate)



(- O - CH2 - CH2 -)9 OH

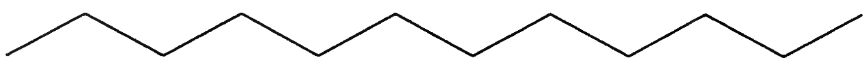
Alkyl Phenyl Ethoxylate (APE) (e.g. nonyl phenyl ethoxylate)



(- O - CH2 - CH2 -)9 OH

Amphoteric Surfactants Contain both anionic and cationic groups.

Carboxybetaine (e.g. dodecyldimethylammoniomethane carboxylate)



CH3
- N+ - CH2 - COO-
CH3

Each of the major classes of surfactants is summarized as follows:

Anionic. These compounds represent, by far the large proportion of surfactant in use, on a mass basis. The detergency of these compounds is vested in anionic functional group(s), which must be neutralized with an alkaline or basic material before full detergency is achieved. Conventional soap molecules, such as sodium stearate (C_{18}), represent carboxylate surfactant, and fall in this class. Linear Alkylbenzene Sulphonate (LAS), the major workhorse surfactant in use for laundry detergents, is also within this class. Other anionic surfactant types in major use include fatty alcohol sulphates (AS), such as lauryl (C_{12}) sulphate and derivatives, which are common in shampoos.

Cationic. The detergency of these compounds is vested in a cationic functional group. Quaternary ammonium salts fall within this class of surfactant. One example is distearyldimethylammonium chloride, which is employed as a fabric softening agent. Such compounds can also exert anti-microbial properties.

Non-ionic. Such compounds contain no ionic constituents, and primarily tend to be ethylene oxide derivatives of fatty alcohols and alkylphenols. These compounds are used in various consumer and industrial products. Although they are produced in smaller overall quantities than anionic surfactant, they tend to represent the largest total revenue category of surfactant, indicating their relative high value. Alcohol or alkyl ethoxylates (AE) represent the major compounds within this class. Alkyl phenol ethoxylates (APE), such as nonylphenyl ethoxylate, also fall within this class.

Amphoteric. Such compounds contain both anionic and cationic groups or functional groups capable for carrying both ionic charges. Amphoteric surfactant, such as alkyl betaines, are used for a variety of specialized functions. For example, because they do not cause eye irritation, amphoteric surfactant are used in baby shampoo formulations.

III.2.2 Builders or Sequestering Agents

Builders are a class of chemical ingredients, primarily involved in laundry detergents but also in other products, that enhance the cleaning action of a surfactant. The main role of these compounds is to remove hard water ions that might interfere with surfactant, especially calcium and magnesium. Builders operate primarily through mechanisms of either ion sequestering or ion exchange. They may also assist in providing a good level of alkalinity for cleaning, and with suspending and preventing soil redeposition.[7]

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7 Ibid, p331.

Each of the four main types of builders are described as follows:

Phosphates. Two kinds of phosphate chemicals are typically employed as builders: orthophosphates; and condensed or complex phosphates. An example of an orthophosphate is trisodium phosphate (Na_3PO_4), which produces a high level of alkalinity, precipitates various metallic ions present in water, disperses dirt, and can dissolve fatty acids via saponification. It is an important constituent in hard surface cleaners. Sodium tripolyphosphate or STPP ($Na_5P_3O_{10}$) is the most widely employed and effective builder agent for heavy duty laundry detergents, and is an example of a complex phosphate builder. Phosphates also act as extremely effective buffering agents. Although highly effective as builders, concerns regarding nutrient loading and eutrophication in effluent receiving streams have resulted in limits being imposed on phosphate use in consumer detergent products.

Silicates. Silicate builders are chemical combinations of sodium oxide (Na_2O) and silica (silicon dioxide, SiO_2). Because they work well on glass or glazed surfaces, they are frequently incorporated into dish washing powder detergents. Silicates also act as inhibitors of corrosion of stainless steel and aluminum by synthetic detergents and complex phosphates.

Carbonates. Carbonates used in detergents and cleaning products include soda ash (sodium carbonate, Na_2CO_3), sodium bicarbonate ($NaHCO_3$), modified soda (sodium sesquicarbonate, $Na_2C0_3{\cdot}NaHCO_3{\cdot}\ H_2O$), and potash (potassium carbonate, K_2C0_3). Soda ash has been long used as a cleaning aid. It provides high alkalinity, and softens water by precipitating calcium and magnesium as carbonates.

Organic Chelating Agents. A variety of organo-carboxylate compounds have been used in relatively smaller qualities in detergent and other cleaning products. The compounds can bind with polyvalent ions, such as calcium and magnesium and other metal ions, to sequester them, forming soluble complexes, and to prevent them from interfering with surfactant cleaning action. Three types of chelating agents have been in use in cleaning products:

- *Aminocarboxylic acids.* Examples of such compounds include ethylene diamine tetra acetic acid (EDTA), which is used in shampoos, nitrilo triacetic acid (NTA) and diethylene triamine penta-acetic acid (DTPA).
- *Hydroxyamino carboxylic acids.* Two main types of such compounds are used: hydroxyethylene diamine triacetic acid (HEDTA), which is essentially ETDA with one carboxylic acid group replaced by an alcohol; and dihydroxyethyl glycine (DEG), which is essentially NTA with two carboxylic acid groups replaced by an alcohol group.
- *Hydroxycarboxylic acids.* Examples include gluconic acid, citric acid and tartaric acid. Sodium citrate ($NaOCO(CH_2CO_2H)_2COH$), for example, has been used as an alternative to phosphates. It exhibits high solubility and sequesters calcium and magnesium, albeit much less effectively than sodium tripolyphosphate.
- *Zeolites.* Zeolites are crystalline aluminosilicates in the form of microsporous framework structures, with void spaces occupied by cations and water. The cations in the structures are mobile and thus can effect ion exchange. Zeolites are employed as builders in powdered

detergent products. The material used are typically Type A zeolites, with empirical composition of $Na_2O{\cdot}Al_2O_3{\cdot}2SiO_2{\cdot}4.5H_2O$, and particle size of approximately 10 mm[8] Such zeolites generally handle calcium ions well, however, the pore size is generally too small to absorb magnesium ions.

III.2.3 Additives

A wide variety of types of additives are employed in formulated soap, detergent and related cleaning products. Some ingredients can perform multiple functions. Major additive groups include the following:

- *Anti-redeposition Agents.* Aid in preventing soil from redepositing on clothes in laundry detergents. Examples include: carboxymethylcellulose (CMC); polyvinyl pyrrolidine (PVP); polyethylene glycol; and polyacrylate. These compounds exhibit high water solubility and compatibility with inorganic salts.

- *Corrosion Inhibitors.* Help protect parts from corrosion effects of cleaners for laundry detergents and industrial cleaners. An example is sodium silicate.

- *Fluorescent Whitening Agents.* Enhance fabric appearance in laundering for laundry detergents. Examples include coumarin or stilbene derivatives.

- *Processing Aids.* Prevent liquid components from separating in liquid products. These components are termed hydrotropes, with examples including sodium and potassium salts of toluene, xylene or cumene sulphonic acids and urea. They help provide free-flowing granules in powdered products.

- *Fragrances.* Provide scent, cover up the chemical odour of ingredients, add individuality and character to product.

- *Colorants.* Add specific colour to product, providing individuality.

- *Bleach/Oxidizers.* Bleaching agents, such as sodium hypochlorite are used for stain removal. Chlorine types provide disinfecting action as well. Given concerns regarding chlorine, non-chlorine bleaching products are becoming more prominent.

- *Suds Control Agents.* Suppress sudsing or provide lasting suds.

- *Fabric Softening Agents.* Impart softness to fabric, control static electricity.

- *Enzymes.* Enzymes are highly active and highly specific biological catalysts that aid in the breakdown of complex soils, especially

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8 Refer to Cahn, A. and J. Lynn. 1983. Surfactant and Detersive Systems. Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed. Vol. 22. pp332-432.

protein-based. The function of the enzymes employed is in cleaving larger macromolecules. In such roles, enzymes are seeing increasing application is laundry detergents and other specialized cleaners, especially for industrial operations. Four main categories of enzymes are typically considered for inclusion: proteases (breakdown proteins to amino acids); amylases (breakdown starch into simpler sugars); lipase (attack fats and oils); and cellulase (attack cellulosic). The use of cellulases has tended to be more limited and is intended more for cotton fabric softening.

- *Fillers.* Provide product bulk. Example in the case of powdered detergents is sodium sulphate.

- *Amines.* Alkaline ammonia derivatives are used in detergent manufacture to add alkalinity to products. Two main types of amines are used: alkylolamines and alkylamines. Cyclohexamine ($C_6H_{11}NH_2$) for example is used in polishes.

- *Superfatting Agents.* Overcome drying effect of soap product on skin (removal of natural oil secretions). Example agents can include lecithin, amine oxides, lanolin, casein, or cocoa butter.

- *Bacteriostatis and Antiseptics.* Provide control or inactivation of microbes, especially for cleaners being used for lower temperature applications where heat inactivation is less likely.

- *Solvents.* Solvents may be included in formulations to aid in removal of greases and oils. Examples can include pine or terpene oils, chlorinated organic, alcohols, glycol, glycohol ethers, and esters.

III.2.4 ACID AND CAUSTIC AGENTS

Acid and caustic agents are used as intermediates in the preparation of other active ingredients for soap and detergent products. At the same time, they are used directly in certain formulated products. They are used directly to a limited extent in consumers products, such as drain cleaners or toilet bowl cleaners. Caustic agents react with fats, oils and greases via saponification. Acids react directly as well, and are especially used for the removal of mineral deposition, such as calcium deposition. Acid and Caustic agents are used especially in industrial formulated products for cleaning, sanitization and surface preparation.

There are five major types of builders: phosphates; silicates; carbonates; organic chelating agents; and zeolites. The majority of materials in use as builders are inorganic compounds. Smaller quantities of organic derivatives are also used.

APPENDIX IV - BACKGROUND ON ADVANCED ANALYSIS METHODOLOGIES

Parsons, R.V. 1997. Lessons in Cost Savings at industrial Plants through Water Conservation and Effluent Improvement. Presentation to Annual Technical Symposium Water Environment Association of Ontario.

This paper contains background on advanced analysis methodologies and other information.

Lessons in Cost Savings at Industrial Plants through Water Conservation and Effluent Improvement

by
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"In our competitive economy, more and more companies are discovering that 'an ounce of prevention is worth a pound of cure'. Waste and pollution are things that you have already paid for, but cannot sell. Preventing their creation before they occur is a better solution, both in terms of dollars and sense, than the old 'end-of-the-pipe' treatment mentality" (1). It's a wonderful phrase that nicely sums up a change in attitude and direction within many industries, away from pollution control to resource conservation and competitiveness.

Water is a key resource used in many industrial operations within Ontario. Unfortunately, it seems that many, if not most, industrial plants in the province were built when water was essentially "free", and this condition is reflected in operations. Water is typically the least monitored and least understood utility in any given plant, unlike, for example, electrical or thermal energy.

This situation, however, is now changing, as companies realize that water consumption and effluent generation are costs that can be avoided. The intent of this paper is to provide an overview of approaches to water-use reduction and effluent improvement, with a focus on prevention and reduction.

Water-Use and Effluent Residuals Generation

Water has a special characteristic for industrial operations. It can act as:

- *Energy carrier*, for example as cooling water or for product heating with either direct or indirect contact involved;

- *Materials carrier*, for example as transport fluid or in rinsing and washing which typically involve direct contact; or

- Both roles simultaneously.

Distinguishing these dual roles provides benefits in enhancing the analysis of water-use and effluent generation, and in opportunities identification. It is specifically important to recognize that the *materials carrier* role of water results in the generation of water-borne process residuals contributing potential pollutants to an effluent discharge. Understanding the importance of resource consumption and residual impacts can be visualized using a Generic Model of Environmental Effects of Industrial Processes, as presented in Exhibit 1.

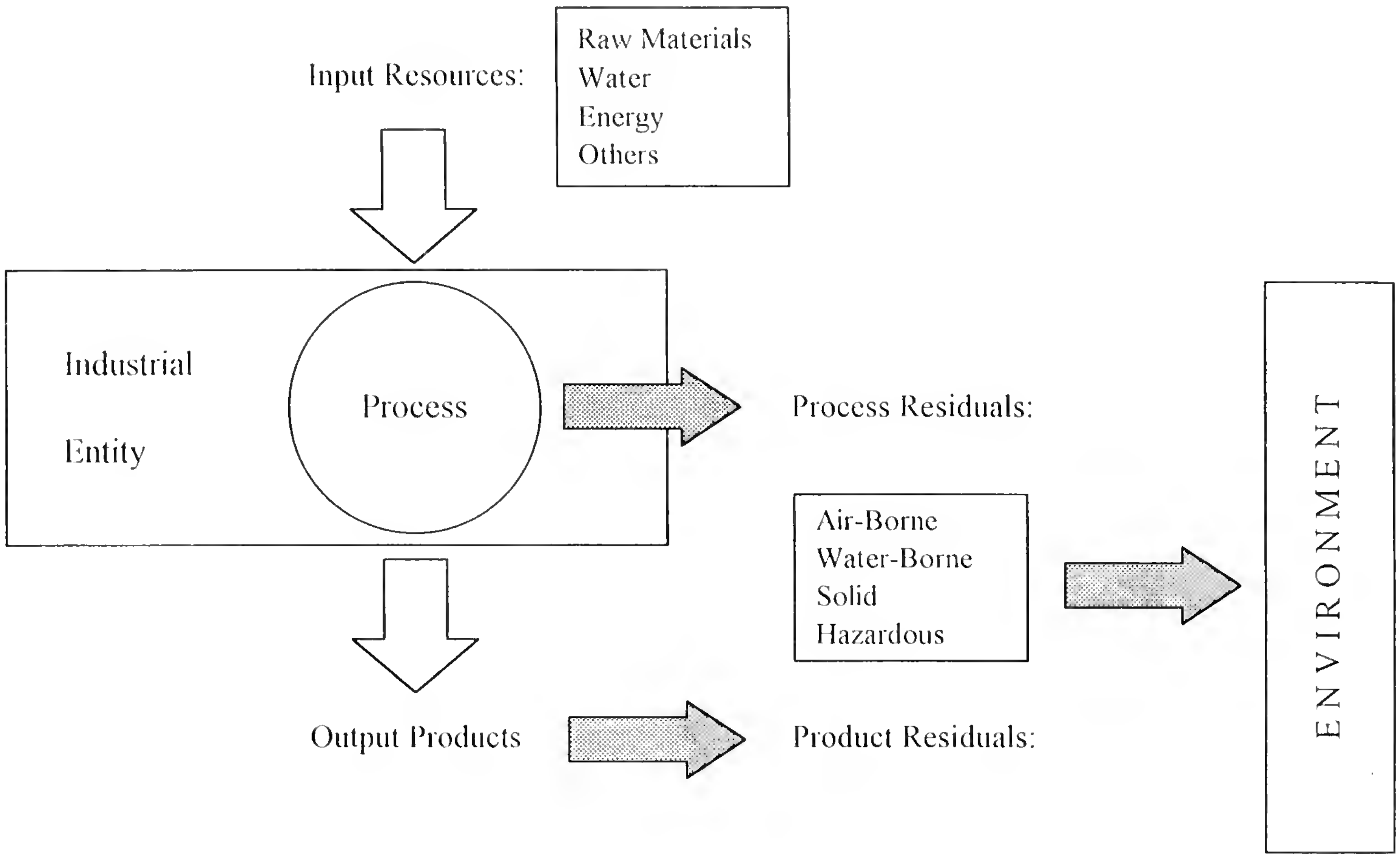


EXHIBIT 1: GENERIC MODEL OF ENVIRONMENTAL EFFECTS OF INDUSTRIAL PROCESSES

Corporate Strategy and Improvement Rationale

Corporate attitudes toward environmental issues have been changing. A variety of relevant frameworks have been developed to describe the changing strategic positions of companies relative to environmental performance. Such frameworks, in general, show a movement from less concern regarding environmental issues to increasing concern. Recognizing the nature of this change is important in order to develop appropriate rationales to justify improvement.

Hart developed a simple, useful matrix, as presented in Exhibit 2, to illustrate these changes (2). Within this matrix corporate perspective is indicated along the vertical axis, ranging from an overview perspective, concerned with the organization as a whole, to a micro-level prespective, concerned with the minute details of operations. Similarly, corporate approach to issues is indicated along the horizontal axis, ranging from a reactive (external) approach to a proactive (internal) approach. The result is four sequential quadrants that define strategic positions, designated as: Denial, Compliance, Competitiveness and finally Sustainability. Currently, most companies tend to reside within the Compliance quadrant, being focussed primarily on ensuring compliance of operational activities with relevant external regulations. The next stage of evolution is towards Competitiveness, which is fortuitous. While not all environmental management imperatives can be described as a "win-win" for both business and the environment, this is very much the case in the movement from Compliance to Competitiveness.

The emerging proactive approaches to environmental improvement have been described by a variety of names. These include:

- Source reduction;
- Waste minimization;
- Pollution prevention (P^2); and
- Design for environment (DfE).

Whatever the term used, the focus of these approaches is on reducing process inefficiencies and associated wastes or residuals that may be generated. As such, they all intrinsically represent forms of *value analysis* or *value-added analysis*, a well recognized and commonly understood approach to business improvement. In this case reducing waste is specifically addressed, rather than reducing servicing time or enhancing customer value as might be emphasized in other systems, but with the same positive competitiveness benefits.

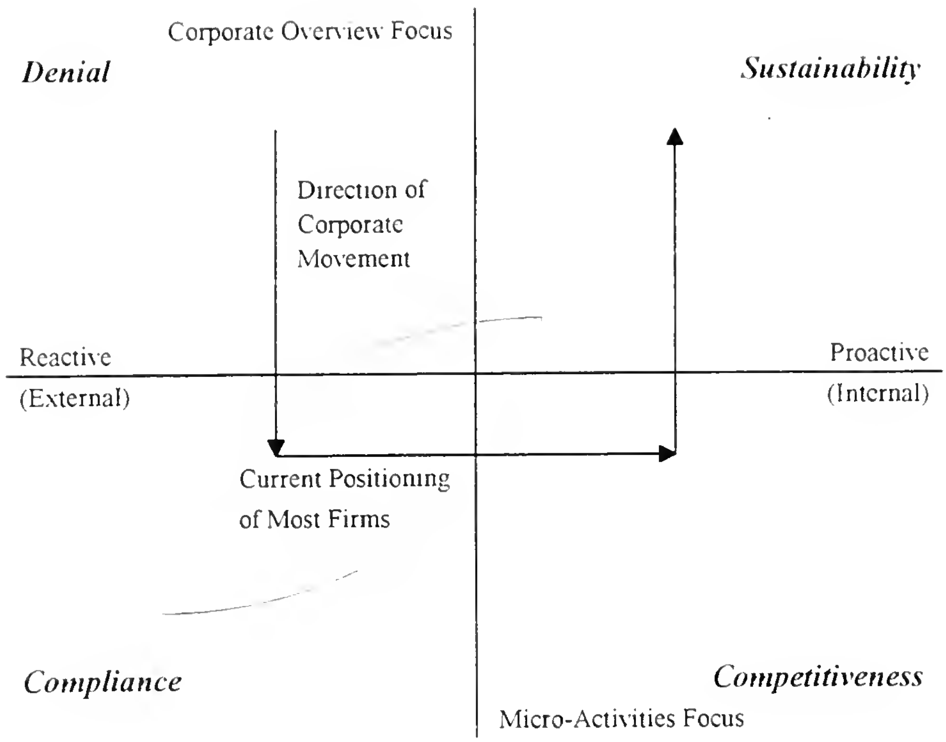


EXHIBIT 2: FRAMEWORK BY HART FOR ENVIRONMENTAL STRATEGY

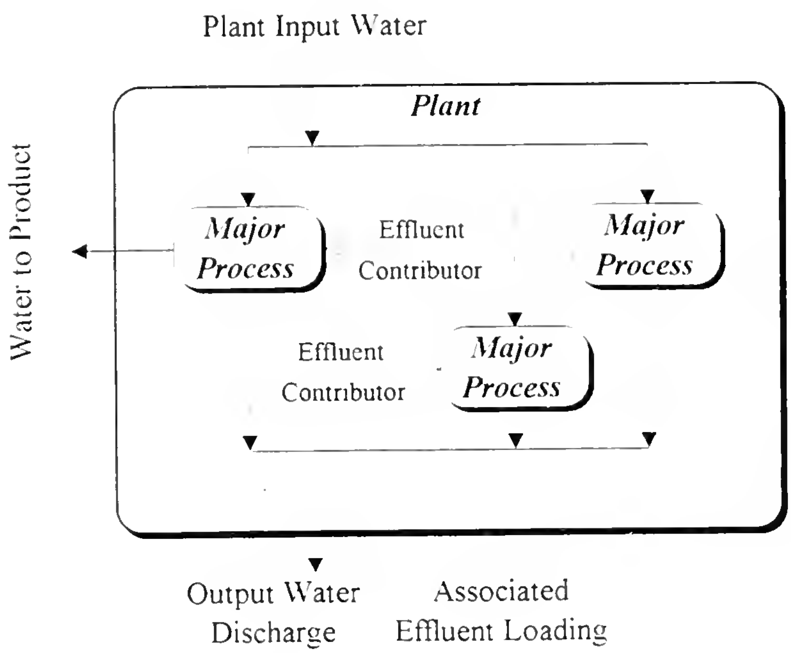


EXHIBIT 3: MATERIAL BALANCES

A perhaps unexpected result of the movement towards Competitiveness is that important future corporate allies are likely to be accountants, who in the past have lacked any degree of visibility with regard to environmental issues. Given their concurrent focus on cost and cost driver identification, and improvement, accountants, especially managerial accountants, will likely play an increasingly crucial role in the future environmental improvement of business operations.

Measurement and Observation Approaches

Determining what is really going on in an industrial plant depends first on measurement. Second, it depends on the ability to assemble data to form reasonably accurate material balances, as illustrated in Exhibit 3. These include:

- Water balances, accounting for where and how much water is being used for different process operations within a plant; and

- Effluent parameter loading balances, such as for BOD, accounting for from where and how much loading is derived from different process operations in a plant.

To help out in regards to measurement, a variety of techniques and devices are available from respective suppliers, ranging from simple to sophisticated, including:

- Water flow measurement for pressurized, full-pipe flows;

- Water flow measurement for open-channel, gravity flows; and

- Sampling and analysis of specific constituents, especially for effluents.

Different techniques and devices each have different advantages and drawbacks, which depend on the specific application, and are not discussed further here. In general, methods are typically available to given reasonable measurements at specific individual locations, and individual personnel involved in plant assessments tend to have favoured approaches.

Perhaps more crucial is the formulation of balances. The use of balances for environmental improvement is well recognized (3,4). In theory, balances are simple. What goes in must equal what comes out. However, difficulties invariably develop in the field, especially when attempting to establish balances around major process operations within a plant.

The problem stems primarily from the reality that water or effluent loading balances are system mass flow balances, and it turns out that achieving closure on such balances is notoriously difficult. In the case of water balances, for example, we have experienced a wide variability of closure at actual facilities, ranging from:

- More than 95% of water accounted for; to

- Less than 40% of water accounted for.

Problems seem to be inherent both in the variability of overall system operations, given that plant activities are dynamic, and in the complexity of feed water and effluent piping or conduit systems. There is inevitably a bypass somewhere. Given this complexity and variability, what if anything can be done?

Based on our experience, a few suggestions can be provided. First and, probably foremost, is something that has often ended up being our secret weapon, namely the *mass and energy balance*. While mass flow can be a difficult thing to measure, temperature is remarkably simple and reliable. All it takes is a thermometer or probe. Because of the linkage of mass flow to total energy content (enthalpy), combined with the basic principle requirement that an energy balance must be achieved, temperature measurements and energy content estimates can be used to validate and/or adjust mass flows. Unfortunately, mass and energy balances have typically seemed to be have been considered the exclusive preserve of industrial process design. They are equally valid when applied for environmental improvement.

A second, related suggestion comes from an old adage from investigative research called the "two plus" rule: don't believe flows or concentrations for individual locations, unless you have at least two sources, measurements or indications that the value is likely to be so. The mass and energy balance, as described above, is a good example of the use of this principle. Another example could be the use of a water flow measurement combined with a pump curve. While a verification is not always possible, this approach it is still useful to keep in mind.

A third suggestion, based on our experience, is that at any given water-use location within a plant, it is usually more reliable to measure in-bound fresh water, than out-bound discharge water.

A fourth and last suggestion is the use of plant production data in balances. This data can be invaluable and usually is remarkably accurate, after all the profitability of a plant depends on it.

Production data is directly relevant in two areas. First, water may be directed into products. Second, and perhaps less obvious, product or other component losses can contribute to effluent parameter loadings. As noted earlier, effluent parameter loadings result directly from process residuals.

Analysis and Optimization Methods

Water-use and effluent generation at industrial plants often can be a bit of a puzzle. Conducting measurements and preparing balances helps to fit all the pieces together to get a bigger picture of what is going on, but once a bigger picture is achieved, what then? There are a number of useful guiding principles, of course, with regard to appropriate water-use and effluent minimization. These include the following:

- Cascading water counter-currently from cleaner applications to dirtier application, rather than using fresh water everywhere.
- Improving housekeeping practices, such as by conducting dry cleanups prior to any washing, and not using hoses as brooms.
- Using screens or other devices to renovate water flows and allow recycle.
- Using nozzles, burst rinses and appropriate devices to restrict water flows to minimum required.
- Using variable speed drives on pumps to adjust water flows in accordance with production rates.

The question, however, may be asked, "Are there systematic methods, that go beyond mere guidance, to assess the appropriateness of process steps, and to optimize?" One such approach that has been successfully applied is Energy Process Integration (EPI). EPI, sometimes referred to as *Pinch* analysis, is a powerful technique that is described below in more detail. A number of other emerging approaches are also described briefly.

EPI was originally developed in the chemical industry for energy utility and cost reduction. The technique provides a comprehensive overview of energy flows within a process plant. Instead of focussing on new, perhaps external energy recovery technologies, EPI analysis goes back to the basics, looking at the actual process to establish the minimum energy requirements to make it work.

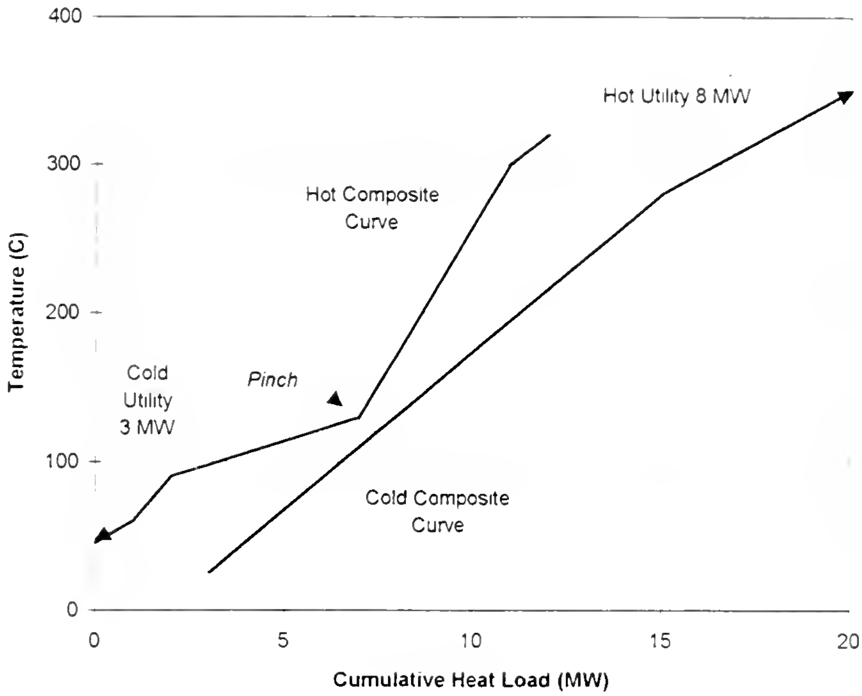


EXHIBIT 4: EXAMPLE HOT AND COLD COMPOSITE CURVES FOR INDUSTRIAL PLANT

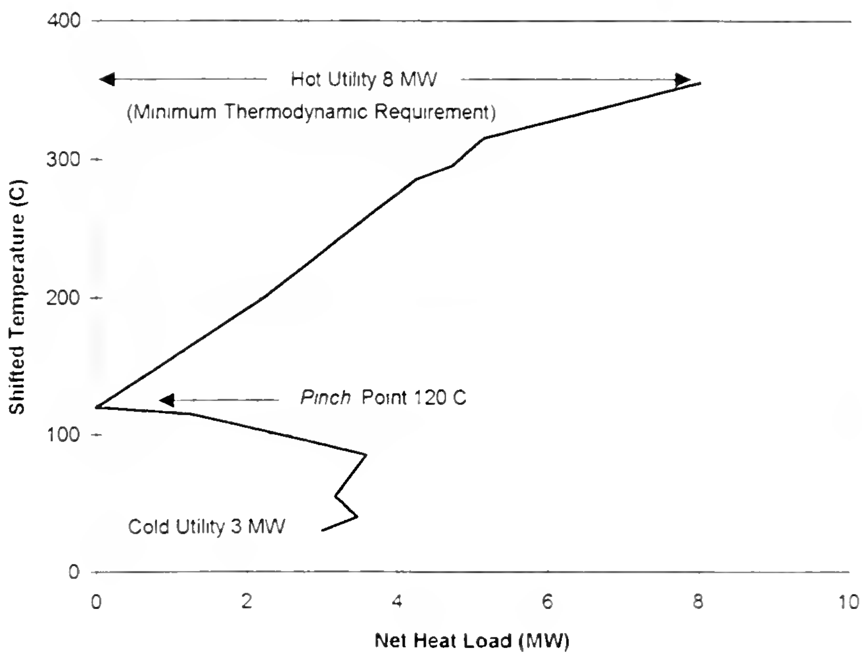


EXHIBIT 5: EXAMPLE GRAND COMPOSITE CURVE

In simple terms, EPI involves the appropriate matching of process streams that need to be cooled (i.e. hot streams that need to give up heat), with process streams that need to be heated (i.e. cold streams that need heating). Composite Hot and Cold Curves for an overall plant can be constructed, as illustrated in Exhibit 4, by combining all individual hot and cold streams respectively. This is analogous to the analysis of hot and cold stream flows through a heat exchanger, but instead looking at the entire plant. The information then can be translated to a so-called Grand Composite Curve (GCC), as illustrated in Exhibit 5, by determining overall net heating or cooling requirements at any given temperature.

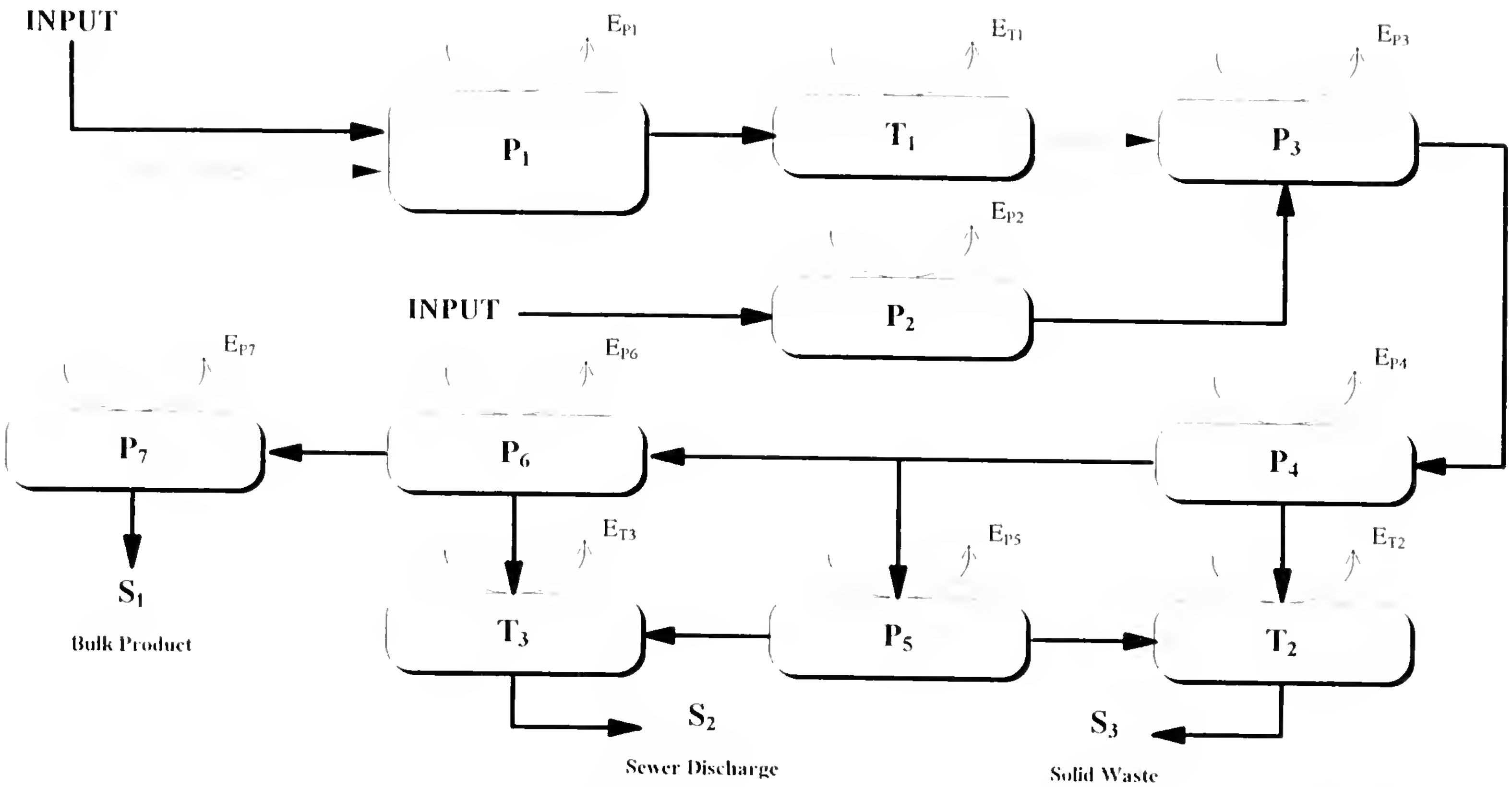
EPI determines the maximum possible overall heat recovery, from which minimum external energy requirements or *targets* can be identified for both hot utilities (e.g. steam) and cold utilities (e.g. cooling water). The curves define thermodynamically feasible minimum target values that can be achieved for a given process. They also define the *pinch* point, or closest overall temperature approach for the entire plant, which has special significance in determining appropriate heat exchange.

It is well and good to save energy, but the question might well be asked, "What about water-use reduction and effluent improvement?" The connection comes implicitly from a characteristic of water described at the beginning of this paper, its key role as an *energy carrier* in many processes. Minimizing energy consumption through EPI in many instances can directly result in reduced water consumption and, thus, subsequent effluent generation as well.

Processes that are large simultaneous consumers of both energy and water, such as brewing, and pulp and paper, are particularly well suited to this approach. Wardrop has been involved is a number of examples of water-use reduction and effluent improvement opportunities in pulp and paper processes, which were developed through the use of EPI (5,6).

EPI, dealing expressly with energy optimization, has now been around for close to 20 years. An interesting and more recent parallel development is a number of techniques that can be described as *Mass Pinch* approaches. Instead of optimizing energy transfer, the objective in this case is to optimize mass transfer, which could include the reduction of effluent contaminant concentrations.

Initial explorations of mass pinch were undertaken by Manousiouthakis and colleagues at the University of California at Davis (7). It has since been picked up by pinch practitioners, who have recently brought software packages for such applications into the market (8,9,10).



Total Process Output

$$= \Sigma E_i + \Sigma S_i$$

(Equipment Emissions + Endpoint Process Streams)

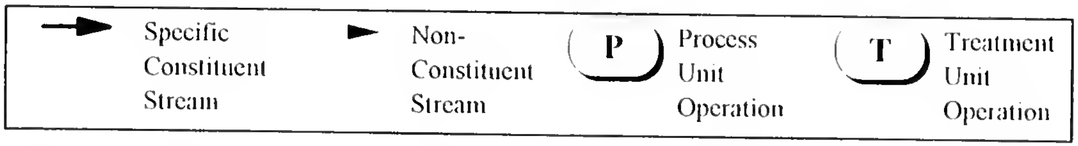


EXHIBIT 6: MICRO-LEVEL ANALYSIS OF EMISSIONS MODEL

While mass pinch approaches are analogous to EPI, they are not a direct translation, and can be much more convoluted in nature. EPI involves thermal equilibrium, and one analysis thus covers the entire process.

Mass pinch, on the other hand, involves multiple mass equilibria, with a concurrent increase in complexity. Potential pollutant contamination in an effluent stream, for example, typically cannot be described in terms of one parameter alone. While mass pinch is still somewhat nascent, this technique appears to offer significant potential in the future.

Another still very nascent approach to analyzing the generation of process residuals is Micro-Level Analysis of emissions (MLA). This technique represents primarily a means to augment the material balance approach, discussed earlier, especially as applied to interactive computer models. Specific constituents of concern typically tend to be negligible from an overall mass and energy balance perspective. As a result, such constituents can be readily tracked by riding on total balances. This modelling approach was recently applied to tracking the inventory of specific chemicals within a pulp and paper facility.

When applied to the evaluation of potential emissions from a specific process, as illustrated in Exhibit 6, two types of unit operations can be defined:

- Regular Processes, involving separation, combination or modification of a process flow; and
- Treatment Processes, specifically intended to treat as an end-point.

At the same time two sources of potential emissions can be defined, as also illustrated in Exhibit 6:

- Process Emissions, which are determined by the process; and
- Equipment Emissions, which specific to the equipment used for each unit operations, whether for processing or treatment.

Based on these definitions and the model structure, as outlined in Exhibit 6, total emissions can be understood as follows:

$$\textit{Emissions} = \Sigma(\textit{Equipment Emissions}) + \Sigma(\textit{Endpoint Process Streams})$$

This approach is somewhat related to emissions-factors, however, it is much more rigorous, providing a systematic, interactive overview of emissions sources, equipment item by item. Optimization routines have not yet been developed, however, the technique can be used to highlight areas for attention.

Opportunity and Technology Trends

Opportunities for water-use reduction and effluent improvement seem to abound in industrial plants, both in their number and their diversity. The selection of appropriate improvement projects depends, of course, on process and site-specific factors. However, based on our experience, an number of generic insights can be provided as to how to develop projects with enhanced viability.

A first trend, alluded to in the discussion of EPI, is the direct linkage of energy-use reduction and environmental improvement. Energy is expensive, so linking projects involving energy, water and effluent improvement savings is advantageous. Consider the following simple illustration:

- Fresh water supplied to an industrial plant from a municipal system in Ontario is typically worth in the range of \$0.30 to \$0.80 per m^3, depending on location and other factors.

- Hot water, say at 70°C, is worth in the range of \$1.00 to \$2.00 per m^3, based on approximate thermal energy prices in Ontario. Displacing hot water obviously saves a lot more money and resources if it doesn't have to be heated in the first place.

A second trend is to recognize that not all water is created equal. As noted above, hot water is worth more than fresh water. Another striking difference is in the high value of chilled water, especially during the summer period. Processed water, such as deionized or reverse osmosis purified water, is also worth more. Avoidance of associated processing costs can often be worth as much or more than the water itself.

A third trend, relevant to effluent improvement, involves emphasizing product or input material savings rather than effluent cost reductions. As noted previously, effluent loadings result from process residuals. In many industries these residuals represent direct product losses. Reducing product and input losses appears to be where large savings can be achieved, especially in such industries as food and beverages.

Consider, for example, the following illustration from the dairy processing industry (11):

- One Litre of milk has an effluent BOD contribution of approximately 0.1 kg. Given a typical surcharge cost for BOD in Ontario in the range of approximately \$0.30 to \$0.50 per kg, the cost of discharging one Litre of milk translates to approximately \$0.03 to \$0.05.

- One Litre of milk has a product value in the range of $0.50 to $0.60, which is an order of magnitude more than the associated BOD charge. Obviously the emphasis in this case should be on reducing product losses, rather than simply reducing effluent discharges.

Improvements can also involve the implementation of new or advancing technologies. There are a wide assortment of emerging technologies specifically relevant to individual industries, however, two generic technology areas appear to offer fairly broad promise in terms of water-use reduction and effluent improvement.

The first is membrane technology. Membranes represent an advanced separation method. They are also still relatively new, with the initial development of practical units less than 40 years ago. The technology has already been employed in an expanding array of applications, including water purification. The development of membranes and systems continues, enhancing potential applications for water reuse and environmental discharge improvement. Given the highly selective nature of membranes they are ideally suited to recovery of specific constituents. Wardrop, for example, has recently been involved with the evaluation of membranes for specialized processing of water, dairy rinse milk recovery, and spent deicing fluid recovery, all of which involve quite unique separation requirements.

The second generic technology area involves detection probes and control system improvements, improving on-line monitoring and control opportunities. Specific probes have become available for on-line detection, for example, of BOD. Such units offer tremendous potential in allowing improved detection and response to discharge loadings. Another area of advance is with various interface detection devices. Such units allow significantly enhanced control of water-product interfaces with reduced associated product losses and effluent contributions.

Benchmarking

One last important development is the increasing application of industry benchmarking of resource-use. Benchmarking of resource-use describes measuring and assessing plant performance relative to available standards. It can represent an important tool, not just for environmental improvement, but also for enhancing competitiveness.

Benchmarking of resource-use can be undertaken by computing overall unit performance ratios (12). The denominator value is commonly total plant product output. Ratios can be calculated for total unit water-use and for total unit generation of various effluent parameters, such as BOD or TSS, as desired.

Benchmarking data can be used by any plant or company in an independent manner to monitor their own progress, such as over time or compared to available literature values. Perhaps more intriguing is the possibility of confidential collection of ratio data on an industry-wide basis to allow comparisons to current industry-wide performance. Such data collection would be conducted through an impartial body in order to provide aggregate information back to participating plants. Being industry-driven, such a procedure would not necessarily involve disclosure to any governmental agency if not desired.

Conclusion

As industries become more oriented towards prevention and conservation, water-use reduction and effluent improvement will become increasingly important, not for compliance but for competitiveness. The tools and techniques are available, or are emerging to ensure that a "win-win" can be achieved for business and the environment.

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APPENDIX V - AGGREGATE SUMMARY DATA ON ENERGY IMPROVEMENT OPPORTUNITIES FROM INDUSTRIAL ENERGY SERVICE PROGRAM (IESP), ONTARIO MINISTRY OF ENVIRONMENT AND ENERGY

APPENDIX V
ENERGY IMPROVEMENT OPPORTUNITIES IDENTIFIED IN THE INDUSTRIAL ENERGY SERVICE PROGRAM

SIC	Description	Capital Cost	Energy Savings
3761	Miscellaneous space HVAC improvements	$10,000	$3,500
	Heat recovery for space heating from process effluent/equipment/exhaust	$2,000	$1,350
	Upgrade and insulate steam lines and distribution systems	$1,000	$600
	Install low wattage fluorescent tubes	$42,000	$11,000
	General HVAC improvements	$44,400	$14,780
	General lighting improvements/Reduce lighting level	$0	$5,123
	Reduction in other electrical utility charges	$0	$45,777
	Efficient equipment use scheduling	$0	$6,945
	Reduce ventilation air to minimum safe levels	$3,500	$1,985
	General refrigeration improvements	$25,000	$14,000
	Power Factor Improvement	$1,000	$840
	Install lighting controls	$0	$491
	Equipment replacement	$22,000	$13,398
	Install energy efficient motors	$2,070	$493
	General lighting improvements/Reduce lighting level	$5,100	$11,000
	Miscellaneous compressed air improvements	$0	$1,000
	Reduce compressed air system leaks	$1,680	$10,200
	Install timed equipment to control HVAC	$2,000	$1,000
	Heat recovery from flue gases for boiler operations	$30,000	$17,000
	Heat recovery from exhaust or effluent streams for process use	$200,000	$72,600
	Heat recovery from flue gases for boiler operations	$20,000	$5,200
	Boiler blowdown heat recovery	$14,000	$5,000
	Heat recovery for combustion air preheat (recuperators)	$123,000	$79,864
	Building infiltration reduction (weather stripping, doors, windows)	$20,800	$25,580
	Upgrade insulation	$7,500	$5,924
	General refrigeration improvements	$15,000	$3,507
	Power Factor Improvement	$7,050	$4,648
	Heat recovery from flue gases for boiler operations	$19,500	$4,531
	Recover waste heat from air compressors for space heating	$10,000	$4,113
	Power Factor Improvement	$5,000	$1,869
	Heat recovery for space heating from process effluent/equipment/exhaust	$137,400	$32,909
	Equipment replacement	$97,500	$14,100
	Optimize motor size load	$860	$200
	Install timed equipment to control HVAC	$2,300	$1,782
	Heat recovery from flue gases for boiler operations	$9,850	$6,928
	Use destratification fans	$15,600	$3,210
	Recover waste heat from air conditioning or refrigeration	$15,000	$6,556
	Miscellaneous compressed air improvements	$40,000	$13,680
	Miscellaneous steam system improvements	$1,300	$1,110
	Miscellaneous steam system improvements	$3,900	$5,787
	Power Factor Improvement	$1,306	$845
	Install lighting controls	$1,000	$1,930
	Recovery of heat from equipment for process use (air compressor)	$2,500	$2,500
	Miscellaneous compressed air improvements	$4,000	$1,315
	Install high intensity discharge (HID) lighting	$4,800	$1,286
	Recover waste heat from air compressors for space heating	$4,364	$4,320
	Install high intensity discharge (HID) lighting	$9,000	$2,285
	Miscellaneous space HVAC improvements	$34,000	$16,290
	Install energy efficient motors	$5,650	$1,384
	Operate HVAC equipment less	$0	$450
	Recover waste heat from air compressors for space heating	$29,100	$9,200
	Power Factor Improvement	$19,500	$5,650
	Replace and upgrade equipment (new boiler, control systems)	$37,200	$10,000
	Install demand controller/load shedder	$0	$20,000

SIC	Description	Capital Cost	Energy Savings
3792	Combustion heat confinement	$10,470	$6,585
	Recovery of heat from equipment for process use (air compressor)	$50,000	$10,000
	Heat recovery from flue gases for process heat	$15,000	$5,000
	General HVAC improvements	$45,000	$27,500
	Steam trap upgrading/repair	$1,200	$14,000
	Reduce compressed air system leaks	$0	$1,525
	Heat recovery for combustion air preheat (recuperators)	$36,200	$10,000
	Building infiltration reduction (weather stripping, doors, windows)	$385	$565
3799	Power Factor Improvement	$5,274	$1,410
	Process design	$100,000	$41,000
	Power Factor Improvement	$3,000	$2,200
	Install high intensity discharge (HID) lighting	$90,000	$22,070
	Set correct fuel/air ratio	$1,000	$2,660
	Heat recovery from flue gases for boiler operations	$14,000	$2,190
	Install demand controller/load shedder	$12,200	$3,490
	Heat recovery from exhaust or effluent streams for process use	$198,700	$73,600
	Upgrade condensate return system	$27,600	$17,800
	Heat recovery from flue gases for boiler operations	$14,000	$3,540
	Use minimum necessary operating steam pressure	$6,000	$4,300
	Rescheduling to avoid peaks	$45,000	$27,331
	Upgrade condensate return system	$233,000	$196,524
	Rescheduling to avoid peaks	$0	$1,405
	Reduction in other electrical utility charges	$7,000	$3,500
	Install demand controller/load shedder	$7,500	$1,600
	Install lighting controls	$7,000	$3,938
	Heat recovery from flue gases for boiler operations	$113,000	$76,000
	Equipment maintenance and repair	$132,500	$147,000
	Install timed equipment to control HVAC	$300	$2,000
	Power Factor Improvement	$15,820	$10,798
	Install lighting controls	$10,300	$7,441
	Boiler maintenance	$9,500	$20,930
	Upgrade insulation	$3,100	$13,000
	Equipment insulation (tanks, hoods, presses)	$2,000	$1,011
	Compressed air	$12,000	$14,850
	Set correct fuel/air ratio	$2,400	$964
	Burner upgrade or replacement	$24,000	$6,000
	Install energy efficient motors	$5,000	$2,028
	Install energy efficient motors	$8,000	$3,550
	Set correct fuel/air ratio	$15,000	$2,900
	Heat recovery from flue gases for boiler operations	$10,000	$2,100
	Install energy efficient motors	$8,000	$4,400
	Steam trap upgrading/repair	$14,000	$4,600
	Set correct fuel/air ratio	$2,500	$4,300
	Power Factor Improvement	$18,630	$6,484
	Replace existing heating system with a radiant heating system	$76,246	$16,700
	Install new or additional insulation	$2,500	$4,250
	Set correct fuel/air ratio	$1,000	$1,880